



Overview of the Arthropod Pests of Citrus Plants in Montenegro

Sanja Radonjić & Snježana Hrnčić

Department for Plant Protection, Biotechnical Faculty, University of Montenegro, 15 Mihaila Lalića Blvd., 81000 Podgorica, Montenegro; E-mail: sanjar@ucg.ac.me

Abstract: Citrus plants (*Citrus* spp.) are among the most important fruit crops in Montenegro. The citrus producing area is located along a coastal plain with a length of 300 km. The satsuma mandarin (*C. unshiu*) is predominantly grown. Here we present a comprehensive review of the arthropod pests associated with the citrus crops in Montenegro. The study was based on previous research and experience, as well as on field surveys that were carried out along the coastal area from 2002 to 2019. The surveys included commercial citrus orchards, nurseries and individual trees in backyards and gardens, which were inspected once per month from April to November every year. Our results revealed 20 pest species recorded on citrus plants at the Montenegro seacoast. They included five species of mites (Acari) and 15 species of insects (Hemiptera, Lepidoptera and Diptera). The three species recorded throughout the whole growing season, most widespread and with the highest abundance were *Aphis spiraecola*, *Phyllocnistis citrella* and *Panonychus citri*. Of them, the spirea aphid *A. spiraecola* was the most common and with the highest population abundance in summer and autumn. Among the recorded species, *Ceratitis capitata* was considered the most important pest for the fruit production, followed recently by *A. spiniferus*. The most damaging for the nursery production was *P. citrella*, followed by *P. citri* and *Dialeurodes citri*.

Key words: *Citrus*, pests, Montenegro coastal area.

Introduction

The genus *Citrus* includes evergreen tree species belonging to the family Rutaceae. The *Citrus* is one of the most important, well-known and widespread tree fruit crop in the world with great economic, social and cultural impact, as well as with high health value. The *Citrus* crops are produced all over the tropical and sub-tropical regions in the world, approximately between 40°N and 40°S latitudes, in more than 140 countries (OLLITRAULT & NAVARRO 2012).

Native to Southeast Asia, over the centuries the citruses have been gradually spread out to various regions of the world by human migrations and

trade. In the 20th century the citruses have become the main crops in various agricultural areas of the Mediterranean, playing an important role in the landscape, in the diet of the overall population, and in the international trade (DUARTE et al. 2016). The first data on citrus fruit in Montenegro dates from the 16th century; 'The garden of oranges' is mentioned in the old Kotor documents from 1598 (KOVIJANIĆ 1963, cited in MIJUŠKOVIĆ 1999).

The area of the Montenegro seacoast is situated between 41°52' and 42°29' north latitudes and 18°26' and 20°22' east longitudes. The Montenegrin coast, due to its specific position within the Mediterranean area, fits into a wider area of citrus cultivation. The satsuma mandarin (*Citrus unshiu* Marc.) is

predominantly grown and is approximately 85% of the Montenegrin citrus production. Around 10% is the share of orange production, while the other species (lemon, grapefruit, and kumquat) are of less economic importance (RADULOVIĆ 1994)

A comprehensive review of the arthropod pests associated with the citrus crops in Montenegro is presented in this paper.

Materials and Methods

The study was based on previous research and experience, as well as on field surveys that were carried out along the coastal area from 2002 to 2019. The surveys included commercial citrus orchards, nurseries and individual trees in backyards and gardens, which were visually inspected once per month from April to November every year along the whole seacoast (from Ulcinj to Herceg Novi) (Fig. 1).

The visual inspections were made by the authors, who were authorised by the Phytosanitary Directorate of Montenegro, Ministry of Agriculture and Rural Development, to do field inspections. The presence of certain species was known from the past, while other species were directly found *in situ*. The collected specimens (samples of adults and immatures) were preserved in 70% ethanol. The symptomatic plant samples were collected for further laboratory examination.

The categorisation of recorded species was performed according to the frequency of occurrence, distribution and abundance in four groups: A. species recorded every year, the most widespread and highly abundant; B. species recorded every year, widespread although with a variation in abundance/presence, depending on the locality/area; C. species recorded every year, not widespread (restricted in some localities/areas); and D. species with sporadic presence, not found every year. All samples were processed according to the standard entomological procedures for morphological diagnostics. In most cases, photographs of the living specimens and/or injury symptoms were taken.

Results

A total of 20 pest species belonging to Hemiptera, Lepidoptera, Diptera and Acari, were recorded on citrus plants at the Montenegro seacoast during this study (Table 1). Of them three species were classified in A category, three species – in B category, three species – in C category, and 11 species – in D category (Table 1).



Fig. 1. Map of Montenegro with main collection sites/areas. 1 – area of Ulcinj; 2 – area of Bar; 3 – area of Budva; 4 – area of Boka Kotor Bay (Tivat, Kotor, Baošići, Đenovići and Herceg Novi).

Discussion

Aphis spiraecola (A)

Aphis spiraecola (= *Aphis citricola* van der Groot) is an accepted name for the spirea aphid (also the green citrus aphid). Probably originates in the Far East and now has a worldwide distribution in the temperate and tropical regions. Although very polyphagous, the *Citrus* species are probably its most important crop host (BLACKMAN & EASTOP 1984).

There are no data regarding the first detection of *A. spiraecola* in Montenegro. MIJUŠKOVIĆ (1999) indicates the presence of *Toxoptera aurantii* B. d. Fonsc. and *Aphis cracivora* Koch on citrus, with the assumption about the presence of *Myzus persicae* Sulz. and *Aphis fabae* Scip. The parasitic wasp *Lysiphlebus testaceipes* Cressonin found in mixed colonies with *A. spiraecola* and *T. aurantii* collected in citrus orchards in 2000 in the area of Tivat and Herceg (TOMANOVIĆ & RADONJIĆ 2001) and the fact that the wasp has become the most common species in the parasitic spectrum of the citrus aphids in Montenegro, presumes the presence of both aphid species before 2002. As a result of our survey, *A. spiraecola* was confirmed as the most abundant species recorded at each inspected locality (Fig. 2).

During 2012–2014, when a particular survey was conducted, this species has been reported as

Table 1. Arthropod pest species recorded on citrus plants during the survey on the Montenegro seacoast.

Rank	Order	Family/Subfamily	Species	Common name	Category
1	Hemiptera	Aphididae	<i>Aphis spiraecola</i> Patch, 1914	Spirea aphid	A
			<i>Aphis gossypii</i> Glover, 1877	Cotton aphid	D
			<i>Toxoptera aurantii</i> (Boyer de Fonscolombe, 1841)	Brown citrus aphid	D
		Aleyrodidae	<i>Dialeurodes citri</i> (Ashmead, 1885)	Citrus whitefly	B
			<i>Aleurocanthus spiniferus</i> (Quaintance, 1903)	Orange spiny whitefly	B
			<i>Aleurothrixus floccosus</i> (Maskell, 1896)	Woolly whitefly	C
		Flatidae	<i>Metcalfa pruinosa</i> (Say, 1830)	Citrus flatid planthopper	C
		Diaspididae	<i>Chrysomphalus dictyospermi</i> (Morgan, 1889)	Dictyospermum scale	D
		Pseudococcidae	<i>Planococcus citri</i> (Risso, 1813)	Citrus mealybug	D
		Coccidae	<i>Saissetia oleae</i> (Olivier, 1791)	The olive scale	D
			<i>Coccus hesperidum</i> Linnaeus, 1758	Brown soft scale	D
			<i>Coccus pseudomagnoliarum</i> (Kuwana, 1914)	Grey citrus scale	D
Monophlebidae	<i>Icerya purchasi</i> Maskell, 1878	Cottony cushion scale	D		
2	Lepidoptera	Gracillariidae, Phyllocnistinae	<i>Phyllocnistis citrella</i> Stainton, 1856	Citrus leaf miner	A
3	Diptera	Tephritidae	<i>Ceratitis capitata</i> (Wiedemann, 1824)	Mediterranean Fruit Fly	B
4	Acari	Tetranychidae	<i>Panonychus citri</i> (McGregor, 1916)	Citrus red mite	A
			<i>Tetranychus urticae</i> Koch, 1836	Two-spotted spider mite	D
		Tarsonemidae	<i>Polyphagotarsonemus latus</i> (Banks, 1904)	The broad mite	D
		Eriophyidae	<i>Aculops pelekassi</i> (Keifer, 1959)	Pink citrus rust mite	C
<i>Aceria sheldoni</i> (Ewing, 1937)	Citrus bud mite		D		

the most widespread and abundant (RADONJIĆ 2014a). Our monitoring of aphids in the main citrus producing areas (Bar and Ulcinj) in 2018 and 2019 also confirmed *A. spiraecola* as the most common and abundant species. During the years of the survey the first colonies were registered in the orchards on new leaves on the spring citrus flush, in April – May. The colonies were present during the whole vegetation season on young leaves of all three citrus flush growth. It was more abundant from the mid-summer and during the autumn (July – October). The species was found both in

the open field and nurseries. Among other aphids, the presence of *T. aurantii* (D) and *Aphis gossypii* Glover (D) was recorded, although in lower density and in smaller area than *A. spiraecola*. In the survey in 2012–2013, *T. aurantii* was more abundant in the area of Herceg Novi.

***Phyllocnistis citrella* (A)**

The citrus leaf miner *P. citrella* is native to the Southeastern Asia and today is distributed worldwide wherever citrus are grown (CABI 2018a). Although polyphagous, it is the primary pest of the genus



Fig. 2. *Aphis spiraecola*: a) colony on mandarin leaf; b) damages on mandarin leaves.

Citrus and related species of the family Rutaceae.

In Montenegro, *P. citrella* was first recorded in 1995 in the area of Ulcinj (ĐIMIĆ et al. 1997). After the first detection its spread was very fast and in less than three years this species has been established in the whole Montenegrin citrus producing area (RADONJIĆ 2002, 2004). During our survey, its presence was detected every year infested all species and varieties of *Citrus* spp. and *Poncirus* sp. at the Montenegrin seacoast (Fig. 3).

Both orchards and nurseries were found infested. In the orchards, the symptoms of infestation were not detected on the spring flush during the whole period of observation. The first visible symptoms were recorded from the end of June till the beginning of July. The increased activity of *P. citrella* was noticed on the summer flush, especially from mid-August. The infestation was the highest on the autumn new growth, in particular, during September and October. In this period was the annual peak of infestation of

the newly formed growth, reaching almost 100%. In nurseries, where usually there are different host plants (citrus, poncirus, kumquat) and the young plants are regularly irrigated and fertilised, and successively and in continuity produce young, new growth, it was found that *P. citrella* can develop continuously, almost all year-round.

***Panonychus citri* (A)**

The citrus red mite *P. citri* is a polyphagous species, found on about 100 host plants. It is best known by its infestation of all varieties and species of citrus. It originates from South-East Asia and now has a worldwide distribution, wherever citrus are grown (ANONYMOUS 2015).

Panonychus citri was first recorded at the Montenegrin coast in Bar in 1950, when it caused serious damages and almost complete defoliation of the citrus trees in the area of Bar. It gradually spread throughout the other parts of the coast (MIJUŠKOVIĆ

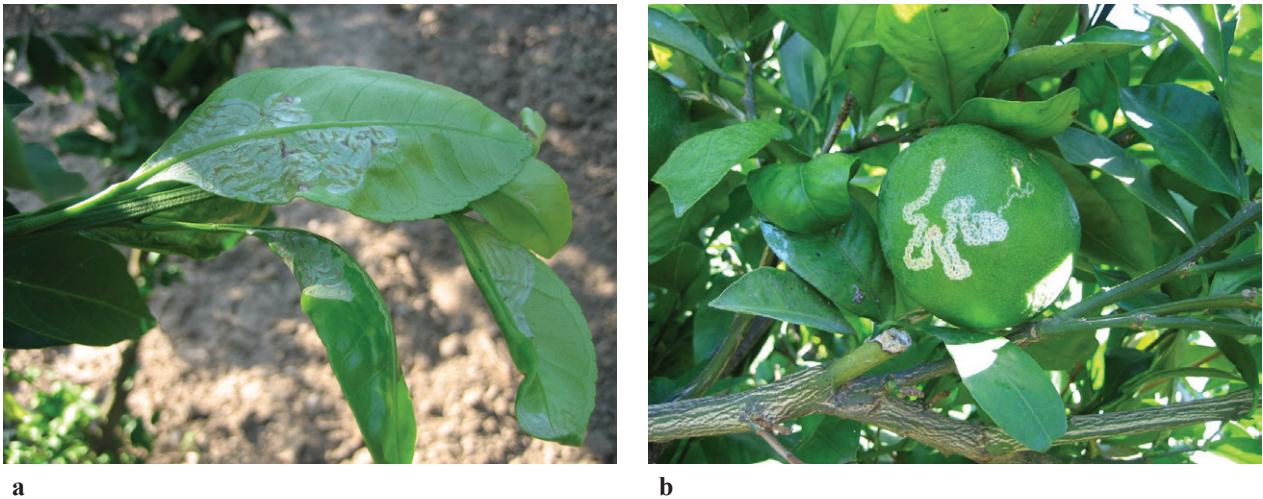


Fig. 3. *Phyllocnistis citrella*: a) typical serpentine mines on underside of mandarin leaves; b) serpentine mines on the fruit rinds.

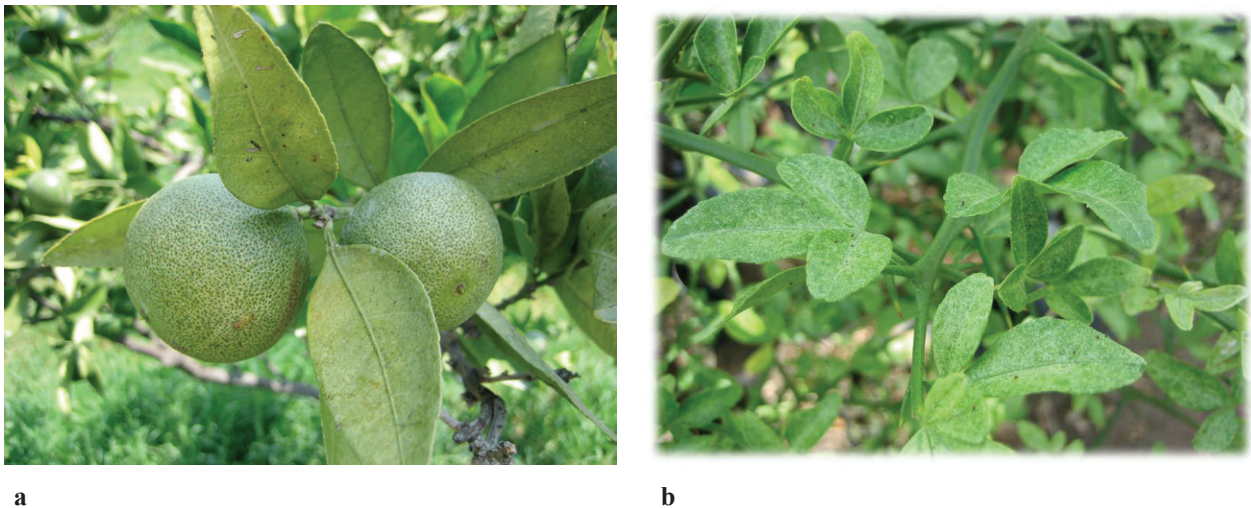


Fig. 4. *Panonychus citri*: a) pale discoloration of mandarin leaves and fruits as a result of feeding; b) symptoms of infestation on *Poncirus trifoliata*.

1999) and now is widespread, present along the entire coastal area, both in the open field and nurseries. The results of earlier studies (MIJUŠKOVIĆ 1999), as well as of our monitoring, showed that more frequently it attacks satsuma mandarins (*C. unshiu*) and lemons, although it occurs also on oranges. In nurseries it was particularly present and usually firstly appeared on *Poncirus trifoliata*, which is almost exclusively used as citrus rootstock.

During the period of this survey, an increase in the population of *P. citri* was recorded during the summer months, particularly July – September, when the damages were the highest (Fig. 4). It was noticed that this species primarily feeds on the upper surface of leaves, but also on fruits and young branches. In our climatic conditions, it can be active during the whole year, although with lower population density in the winter months. In 2010 severe infestations were

recorded in several mandarin orchards in the area of Bar and Ulcinj. Nymphs and adults were accidentally found in January and February 2014 in Bar. In nurseries the species can be active all year round if host plants are present. According to MIJUŠKOVIĆ (1999), in Montenegro *P. citri* can develop 15 generations, with two generations per month in summer.

***Dialeurodes citri* (B)**

The citrus whitefly *D. citri* is considered to be of oriental origin, probably Indian. Today its distribution is worldwide. It is one of the most polyphagous whiteflies and one of the most important pests of *Citrus* spp. (CABI 2017).

The first records for Montenegro date from the 1970s in the area of Tivat. In the following years it has spread throughout the other part of the seacoast (MIJUŠKOVIĆ 1999). During our survey, *D. citri* was



Fig. 5. *Dialeurodes citri*: numerous adults on underside of mandarin leaves.

recorded every year, being more abundant in the localities from Herceg Novi to Budva, than in the area of Bar, and particularly of Ulcinj. Its presence was registered in the majority of the inspected nurseries, mostly in the mid-of-July, August and September (Fig. 5).

The first symptoms were noticed during April and May. The increase of the population and mass egg laying started from the end-May or in the beginning of June, and consequently the higher population density was observed in the period of June – September. Since 2013–2014 lower population density of the pest was recorded at all inspected localities. The pest was not found on kumquat and *P. trifoliata*.

***Aleurocanthus spiniferus* (B)**

The orange spiny whitefly *A. spiniferus* originated in the southeastern Asia and has spread widely in tropical and subtropical Asia, Africa and the Pacific. In Europe it was reported for the first time in Italy in 2008 (PORCELLI 2008), and later on, in Croatia in 2012 (ŠIMALA & MASTEN MILEK 2013) and Greece in 2016 (KYPRIOTIS et al. 2017). The species is listed as a quarantine threat to Europe and is included in the EU Annex II/A1 and in the EPPO A2 list. Although it is highly polyphagous, the main hosts of economic importance are *Citrus* spp. (CIOFFI et al. 2013).

Aleurocanthus spiniferus was first reported from Montenegro in October 2013, in citrus orchards in the area of Boka Kotor Bay (RADONJIĆ et al. 2014). In 2014 it was recorded for the first time in the locality Šušanj (area of Bar) in a small mixed citrus orchard with several mandarin, orange and grapefruit trees. The monitoring in 2015 resulted in confirmation of the same localities as in the previous year, while in 2016 and 2017, its spread in



a



b

Fig. 6. *Aleurocanthus spiniferus*: a) underside of orange leaves with numerous puparia; b) heavy sooty mould on orange leaves.

the same area was observed (RADONJIĆ & HRNČIĆ 2017). Since 2017 it has been found alongside a wide area of citrus production from Bar to Herceg Novi, with the exception of Ulcinj area (RADONJIĆ 2017, 2018). During the monitoring period it was noticed that in some cases the infestation was followed by serious damages as a result of feeding and excretion of copious honeydew, which coated the leaves, branches and fruit surfaces, as well as



Fig. 7. *Ceratitiss capitata*: a) adult on mandarin fruit; b) damaged mandarin with typical signs on the outside of the fruit.

by quick growth of heavy black sooty mould. The severe infestations resulted in almost completely black appearance of the infested citrus plants and drying (Fig. 6). Because of the repeated severe infestations, mass falling of leaves was recorded in several citrus orchards in the localities Baošići and Kumbor (in the area of Boka Kotor Bay) in 2016 and 2017, which resulted in the reduced growth of the young leaves, flower and fruit settings in the next vegetation season. During the period of the survey the first deposit eggs were found in mid-May and the infestations increased during the spring and summer season. A peak of the adult population usually appeared in mid- or late July and early or mid-September. During this survey *A. spiniferus* was not recorded in the area of Ulcinj and there were no signs of its presence in nurseries.

***Ceratitiss capitata* (B)**

The Mediterranean fruit fly *C. capitata* is one of the most widespread pest species in the family Tephritidae. As a highly polyphagous one that infests the fruits of 374 species, it is marked among the world's most damaging pests for fruits and vegetables (LIQUIDO et al. 1998). Despite its Afrotropical origin it is the only species within the genus *Ceratitiss* that readily colonises tropical and mild temperate habitats far outside of its home range (GILSTRAP & HART 1987, cited in DE MEYER et al. 2002).

In Montenegro *C. capitata* is considered as one of the key citrus pests, established in the early 2000s. However, its presence in the Mediterranean region for more than 100 years was not a subject to permanent monitoring in Montenegro. Some reports mention the sporadic detection and very low population densities in the past (MIJUŠKOVIĆ 1959, VELIMIROVIĆ 1988, 1989,

1990). Continuous monitoring using different types of traps (McPhail, Tephri and Jackson) and attractants (angelica seed oil, hydrolysed protein and ammonium salt, para-feromone Trimedlure and 3-component female biased dry food attractant) started in 2002 and is still ongoing. The results of the monitoring showed the presence of *C. capitata* alongside the whole coastal area, with higher population numbers in the western part (the area of the Boka Kotor Bay) and with distinct seasonal population fluctuations (RADONJIĆ et al. 2013). In general, the captures of flies were recorded from the end of June until the end of December. The population density was very low in July and August; it increased slowly from the end of August through the first half of September and peaked from mid-September to the end of October. The adult activity ended in December (RADONJIĆ et al. 2013). The infested citrus species that have been detected since 2002 include mandarins, oranges, lemons, and grapefruits. In terms of economic impact, the infestations of mandarins have been of key importance for the citrus production in Montenegro (Fig. 7). During the monitoring period, the first symptoms were noticed on the earliest mandarin varieties (*Wakiyama* and *Chahara*) from mid- to late September, while on the later varieties (Satsuma mandarins, mandarin Unshiu – variety *Owari*) the symptoms were observed from October to mid-November.

***Aleurothrixus floccosus* (C)**

The woolly whitefly *A. floccosus* is of neotropical origin. In the early 1970s it was reported in Europe (Spain and southern France), and later recorded in other countries in the western and southern Mediterranean Basin and the Middle East (CABI 2018b). Although this species is polyphagous, in



Fig. 8. *Aleurothrixus floccosus*: larval instars on underside of mandarin leaves covered with white waxy filaments.

the newly introduced environment, such as the Mediterranean, it shows marked preference for the family Rutaceae, particularly for the genus *Citrus* (CRAVEDI et al. 2008, CABI 2018b).

In Montenegro *A. floccosus* was first recorded in 2001 in one citrus producing orchard in Budva (RADONJIĆ & HRNČIĆ 2003) (Fig. 8). In the following years, the species was not found out of its first detection site. The first symptoms outside the area of Budva were recorded in July 2013 in the citrus orchards of Bar, and in 2014 in the area of Bar and Ulcinj (RADONJIĆ 2014b) and in the area of Boka Kotor Bay, at the localities Baošići, Đenovići, and Herceg Novi. Although the pest showed slow and gradual spread in the following years, and currently is present in wider part of the coast (Boka Kotor Bay, Budva, Bar, Ulcinj), its population density was ranked as low at all localities, where its presence was confirmed. It was noticed that the colonies were usually developed together with *D. citri*, and less commonly with *A. spiniferus*. The visual inspection showed (similar with other two aleyrodid species) that after its overwintering (in the nymphal stage) the population continued its development in the beginning of the spring. New visible symptoms were usually recorded from May – June, when adults' appearance was also noticed. The first eggs in the characteristic circular or semicircular patterns, usually surrounded by light dusting of waxy scales, were recorded in June. During the monitoring period there were no signs of pest presence in the nurseries.

***Metcalfa pruinosa* (C)**

The citrus flatid planthopper *M. pruinosa* is nearctic species recorded for the first time in Europe from Italy (1979), and then spread and established in many other European countries (CABI 2018c). It is



Fig. 9. *Metcalfa pruinosa*: adult and waxy exudate on the terminals of mandarin twig.

highly polyphagous and found on a wide range of woody and herbaceous plants, in addition to citrus.

After its first detection in Montenegro in 2003, in the area of Skadar Lake, on *Robinia pseudoacacia* (HRNČIĆ 2003), this pest spread throughout the coastal area (Bar and Ulcinj) (HRNČIĆ et al. 2007). The visual inspections showed its presence on a wide number of ornamental and cultivated plants, on fruit species, and particularly on citrus (Fig. 9). The presence of *M. pruinosa* on citrus was recorded both in the orchards and in the nurseries (particularly in the area of Bar). Its gradual spread in the rest of the seacoast (from Budva to Herceg Novi) with scarce presence on citrus was observed since 2009. The larvae predominated in June, while the adults in July, with decreasing number in August. In several cases we noticed single adults, the latest was in mid-September. During this survey, *M. pruinosa* was found to be more abundant in the area of Bar and Ulcinj than in the other parts of the seacoast. Our results showed that in the recent years the presence of *M. pruinosa* was not as abundant as in the years after its first detection. In 2018 it was not found on citrus, neither in the orchards nor in the nurseries.

***Aculops pelekassi* (C)**

The pink citrus rust mite *A. pelekassi* is a pest widely distributed in most of the citrus-growing areas of the world (TSUCHIDA & MASUI 2020).

In Montenegro, *A. pelekassi* was registered for the first time in 1962 in Bar (MIJUŠKOVIĆ 1999). Now it has been present along the whole seacoast although not abundant. A greater number was registered in the area of Bar and Ulcinj (Fig. 10). In 2010 it was found more abundant in several citrus orchards in the area of Budva (Lastva Grbaljska). Sporadic presence was noticed in the area of Boka Kotor Bay.



Fig. 10. *Aculops pelekassi*: ‘bronzing’ of infested mandarin fruit.

According to MIJUŠKOVIĆ (1973), *A. pelekassi* overwinters in citrus buds, usually from October to April. During our survey, the first symptoms of fruit distortion were registered from mid-August and in September. It was also found that the species caused the most severe damages to *C. unshiu*, and to oranges. In 2003–2005, serious damages were registered in the several mandarin orchards in the area of Bar and Ulcinj. The damages were particularly visible on fruits. The species was not registered in nurseries.

***Chrysomphalus dictyospermi* (D)**

The dictyospermum scale *C. dictyospermi* is native to the southern China and is widely distributed in the tropical and subtropical areas. It is present in many Mediterranean countries (CABI 2018d). It is highly polyphagous with *Citrus* spp. as one of the principal hosts (BAYINDIR & BIRGÜCÜ 2016 and references therein).

In Montenegro, the species was found along the whole seacoast, although its presence was limited to single citrus trees, or orchards. It was found primarily on leaves and fruits (Fig. 11). During 2009–2011 severe infestations of certain single trees were recorded at the localities of Đenovići, Herceg Novi, and Tivat, in September and October. The first visible symptoms were detected in June and early July. The pest was sporadically found in nurseries, except in 2007 and 2010, when severe symptoms were registered on lemon and mandarin nursery plants at Bar and Đenovići.

***Planococcus citri* (D)**

The citrus mealybug *P. citri* most probably originated from China; now the species is distributed worldwide. It is polyphagous, although mostly present on different citrus species, especially on lemon, orange



Fig. 11. *Chrysomphalus dictyospermi*: colony and symptoms on infested leaves and fruit.



Fig. 12. *Planococcus citri*: damage on fruit.

and mandarins. It causes the highest damages on *Citrus* spp. among all mealybugs in the Mediterranean region (CRAVEDI et al. 2008, CABI 2018e).

During the period of our survey *P. citri* was found sporadically along the whole seacoast, though more frequently in the area of Boka Kotor Bay. In 2010–2011 severe infestations of the orange trees were registered at two localities in Herceg Novi (in the urban area of the city) and at one locality in Kumbor, Đenovići, and Tivat. Infestations occurred on single citrus trees (Fig. 12). At the locality Đenovići in small mixed orchards, in which up to 10 citrus trees were grown, the infestations were detected only in two trees positioned in the shady part of the property. In 2012 and 2015 similar infestation was observed at one locality in Bar. Severe symptoms of infestation were recorded from July and in the following months. At one locality in Herceg Novi *P. citri* was found on lemon. The pest was not found in nurseries.



Fig. 13. *Icerya purchasi*: adults and juveniles on a citrus leaf.



Fig. 14. *Saissetia oleae*: scale on a citrus twig.

Icerya purchasi (D)

The cottony cushion scale *I. purchasi* is of Australian origin, but has become a cosmopolitan pest, distributed throughout the tropic and sub-tropic regions. It is polyphagous with wide host range. The most preferable citrus species were the orange and clementine trees (POLLINI et al. 2002, CRAVEDI et al. 2008).

At the Montenegro seacoast, *I. purchasi* was found in the 1950s, in the area of Herceg Novi and Bar, although only on single citrus trees. Even later no serious damages were observed (MIJUŠKOVIĆ 1999). During our survey it was recorded at almost all localities, on single trees, usually on the young branches, the underside of the leaves, and the stems of the fruits (Fig. 13). In 2013–2015, *I. purchasi* was more abundant at some localities in Bar, Ulcinj and Herceg Novi, but not widespread within the inspected orchards. No serious damages were recorded during this survey. The pest was found in nurseries in Bar in several consecutive years (2010–2017) and at Herceg Novi in 2017.

The olive scale *Saissetia oleae* (D)

The olive scale *S. oleae*, which originated from South Africa, is now distributed worldwide. It is a polyphagous species and an important pest on the olive and citrus trees (CRAVEDI et al. 2008, BYRON et al. 2015, CABI 2018f).

During our survey this species was detected along the whole seacoast, although slightly more numerous in the area of Bar and Ulcinj (probably because this is the most important olive growing region in Montenegro) (Fig. 14). The presence of the pest was usually registered on single trees or small group of citrus trees. The pest was not found in nurseries.

Coccus hesperidum (D)

The brown soft scale *C. hesperidum* is a cosmopolitan and polyphagous pest species widely distributed in the tropical and subtropical regions. It causes occasional problems on citrus plants (OEPP/EPP0 2004).

The species was detected in Montenegro during the 1950s. It was recorded along the whole coastal area, on all citrus species, and occasionally of higher abundance (MIJUŠKOVIĆ 1999). During our survey it was found along the whole seacoast, usually on single citrus trees in the backyards and occasionally on nursery plants (Fig. 15). In 2008, 2011, and 2012 severe infestations of single citrus trees (mandarin and orange leaves) were registered in the areas of Bar and Tivat.

Coccus pseudomagnoliarum (D)

The grey citrus scale *C. pseudomagnoliarum* is of Asian origin. In Italy, after the first detection in 1970, it was considered among the most harmful citrus pests. Nowadays, it has become very rare in citrus fruit areas. According to MASTEN MILEK et al. (2017) *C. pseudomagnoliarum* is widespread on citrus plants within the majority of the Croatian coastal area and has significant economic impact.

This species was recorded in Montenegro in 1964 and considered to be present on citrus species along the whole coastal area. In the past, the pest was the most widespread and abundant coccid on citrus species in Montenegro (VELIMIROVIĆ 1986). The same author listed the coccid species found on citrus species in the southern part of Montenegro with special emphasis on *C. pseudomagnoliarum*. The presence of parasitoid species (Aphelinidae, Encyrtidae) and predators (Coccinellidae, Miridae) recorded by VELIMIROVIĆ (1986, 1994) has an important role in maintaining the balance of the natural conditions and decreasing the population of *C. pseudomagnoliarum*.



Fig. 15. *Coccus hesperidum*: infested leaf and sooty moulds developed on excreted honeydew.

with around 80%. During our survey the pest was found both in orchards and nursery plants, although not abundant. It was found on single citrus trees, developing colonies on their leaves and branches (Fig. 16). It was not found on fruits.

***Aceria sheldoni* (D)**

The citrus bud mite *A. sheldoni* commonly infests the lemons and, in some regions of the world, also the sweet oranges (var. Navels, Valencia) and other species and varieties of citruses (JEPPSON et al. 1975, VACANTE & BONSIGNORE 2016).

In Montenegro this species was officially confirmed to be present along the whole seacoast in 1969 (MIJUŠKOVIĆ & TOMAŠEVIĆ 1975). During our survey, *A. sheldoni* was found more frequently in the area of Bar on single lemon trees and in nurseries also on lemons (Bar, Đenovići, Ulcinj) (Fig. 17). The characteristic symptoms of the infestation were shortened twigs with weak growth. The leaves produced on those twigs were small and malformed with irregularly indented margins. The infested fruits showed serious malformation.

***Polyphagotarsonemus latus* (D)**

The broad mite *P. latus* is spread worldwide, highly polyphagous and capable of attacking more than 60 botanical families (PETANOVIĆ 2004). It is distributed in the field in tropical regions and in greenhouses in temperate regions on numerous agricultural crops, ornamentals, and wild plants (JEPPSON et al. 1975).

The pest was detected for the first time in Montenegro in 2006, on sweet pepper in several greenhouses near the city of Podgorica (HRNČIĆ & RADONJIĆ 2010). During a regular inspection of nurseries in 2009, at the locality of Đenovići, it was found on the mandarin, lemon and orange nursery



Fig. 16. *Coccus pseudomagnoliarum*: colony on a twig.

plants with symptoms of leaves distortion: leaves light green and rough, narrowed, crinkled and distorted with downward curled margins or without developed one half of the leaf; internodes detected as shorter than normally (Fig. 18). This was the first and the only confirmation of its presence on citruses in Montenegro (RADONJIĆ & HRNČIĆ 2010).

***Tetranychus urticae* (D)**

The two-spotted spider mite *T. urticae* is a cosmopolitan and the most polyphagous species of the spider mites reported from over 150 host plant species of economic value (ZHANG 2003). It is one of the key pests of citruses in the Mediterranean region and a key pest of citruses in Spain, especially of clementines (ABAD et al. 2006).

In Montenegro, this species was first detected in 2004 on citrus plants in one nursery at the locality of Đenovići. At the same locality, the pest was found on lemon and orange nursery plants in 2005, as well as on mandarins in 2006. In 2007 the infestations were detected for the first time outside the nursery, in a mandarin producing orchard in Ulcinj (RADONJIĆ 2007). The initial symptoms of infestation in orange and mandarin trees were visible on the upper leaf



Fig. 17. *Aceria sheldoni*: heavy distorted lemon fruit.



Fig. 19. *Tetranychus urticae*: concavities on the underside of a leaf with slight webbing.



Fig. 18. *Polyphagotarsonemus latus*: heavy distorted leaves of an orange nursery plant.

side as a slightly elongated protuberance, which turns yellowish over time (Fig. 19). On the lower surface, there was a corresponding concavity, where the webbing was formed. In lemons, the initial symptoms were chlorotic spots visible on both sides of the leaf. The appearance of a slight protuberance on the upper leaf side that gradually changes its colour from yellow to bronze was a later symptom. After 2009 the presence of *T. urticae* was not recorded in the nursery

at Đenovići or in any other of the inspected nurseries. The species population was very low in the citrus producing orchards in Ulcinj in 2008 and 2009. The situation was the same in Bar in 2012.

Conclusions

Our review of published and field survey data revealed a total of 20 pest species recorded on citrus plants at the Montenegro seacoast. They included five species of mites (Acari) and 15 species of insects (Hemiptera, Lepidoptera, and Diptera). The three species recorded throughout the whole growing season, most widespread and with the highest abundance were *A. spiraecola*, *P. citrella*, and *P. citri*. Of them, the spirea aphid *A. spiraecola* was the most common and with the highest population abundance in summer and autumn. Among the recorded species, the Mediterranean fruit fly *C. capitata* was considered the most important pest for the fruit production, followed recently by the orange spiny whitefly *A. spiniferus*. The most damaging for the nursery production was the citrus leaf miner *P. citrella*, followed by the citrus red mite *P. citri* and the citrus whitefly *D. citri*.

Acknowledgements: We are grateful to the Directorate for Food Safety, Veterinary and Phytosanitary Affairs, and the Ministry of Science of Montenegro for the continual financial support. We would like to thank the Ministry of Science for funding a bilateral project between Montenegro and PR of China: 'Pests from order Hemiptera (Aphididae, Aleyrodidae and Psyllidae) on citrus and their natural enemies in Montenegro and PR of China' (2013–2014). We are also grateful to the entomology technician Milorad Raičević for his help in the field and laboratory work, and especially to the fruit producers and growers who allowed us to conduct sampling from the infested plants and to set up traps in their orchards throughout the years of this survey.

References

- ABAD R., CASTAÑERA P. & URBANEJA A. 2006. Natural enemies of the spider mites, *Tetranychus urticae* Koch. and *Panonychus citri* McGregor (Acari: Tetranychidae) in Spanish citrus orchards. Abstract. IOBC/WPRS Bulletin 29 (3): 179.
- ANONYMOUS 2015. *Panonychus citri* (McGregor). Available at: http://www.agri.huji.ac.il/mepests/pest/Panonychus_citri/, Page last update 3. 23.2015
- BAYINDIR A. & BIRGÜCÜ A. K. 2016. Effect of temperature on life history of *Chrysomphalus dictyospermi* (Morgan) (Hemiptera: Diaspididae). Redia 99: 145–149.
- BLACKMAN R. L. & EASTOP V. F. 1984. Aphids on the world's crops: An identification and information guide. London: John Wiley Sons, 476 p.
- BYRON M. A., GILLET-KAUFMAN J. L. & ALLAN S. A. 2015. Black scale, *Saissetia oleae* (Olivier, 1791) (Insecta: Hemiptera: Coccoidea: Coccidae). University of Florida / Institute of Food and Agricultural Sciences (UF/IFAS) Extension Publications No. EENY 620: 1–4. Available at http://entnemdept.ufl.edu/creatures/CITRUS/black_scale.htm
- CABI 2017. *Dialeurodes citri* (citrus whitefly). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/18698>, Last modified 11 October 2017.
- CABI 2018a. *Phyllocnistis citrella* (citrus leaf miner). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/40831>, Last modified 20 November 2018.
- CABI 2018b. *Aleurothrix floccosus* (woolly whitefly). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/4538>, Last modified 13 November 2018.
- CABI 2018c. *Metcalfa pruinosa* (frosted moth-bug). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/35054>, Last modified 14 July 2018.
- CABI 2018d. *Chrysomphalus dictyospermi* (dictyospermum scale). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/13378#6BDB142B-FB55-4E64-AA49-4B46CF3DF7A7>, Last modified 27 March 2018.
- CABI 2018e. *Planococcus citri* (citrus mealybug). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/45082>, Last modified 27 September 2018.
- CABI 2018f. *Saissetia oleae* (olive scale). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/48204>, Last modified 03 January 2018.
- CIOFFI M., CORNARA D., CORRADO I., JANSEN M. G. M. & PORCELLI F. 2013. The status of *Aleurocanthus spiniferus* from its unwanted introduction in Italy to date. Bulletin of Insectology 66 (2): 273–281.
- CRAVEDI P., MAZZONI E., PASQUALINI E., PELLIZZARI G., RAPISARDA C., RUSSO A., SUMA P. & TRANFAGLIA A. (Eds.) 2008. Psille, cocciniglie e aleirodidi. Milano: Edizioni L'informatore agrario, 183 p. (In Italian).
- DE MEYER M., COPELAND R. S., WHARTON R. A. & MCPHERON B. A. 2002. On the geographic origin of the Medfly *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae). In: Proceedings of the 6th International Fruit Fly Symposium, Stellenbosch, South Africa, pp. 45–53.
- DIMIĆ N., SPASIĆ R., PERIĆ P. & HRNČIĆ S. 1997. Citrus leaf miner – *Phyllocnistis citrella* Stainton (Lepidoptera, Phyllocnistidae), a new pest in Yugoslavia. [Miner lista agruma – *Phyllocnistis citrella* Stainton (Lepidoptera, Phyllocnistidae), nova štetočina u Jugoslaviji.] Plant Doctor. [Biljni Lekar.] 25 (6): 623–625. (In Serbian).
- DUARTE A., FERNANDES J., BERNARDES J. & MIGUEL G. 2016. Citrus as a component of the Mediterranean diet. Journal of Spatial and Organizational Dynamics 4 (4): 289–304.
- HRNČIĆ S. 2003. *Metcalfa pruinosa* Say (Homoptera, Flatidae) a new polyphagous pest. [*Metcalfa pruinosa* Say (Homoptera, Flatidae) nova polifagna štetočina]. Plant Doctor. [Biljni Lekar.] 5: 515–516. (In Serbian).
- HRNČIĆ S., PEROVIĆ T. & RADONJIĆ S. 2007. *Metcalfa pruinosa* Say (Flatide, Homoptera) – invasive species, distribution and plant hosts in Montenegro. [*Metcalfa pruinosa* Say (Flatide, Homoptera) – invazivna vrsta, rasprostranjenost i biljke domaćini u Crnoj Gori]. Agro-knowledge Journal. [Agroznanje] 8 (4): 23–29. (In Serbian).
- HRNČIĆ S. & RADONJIĆ S. 2010. *Polyphagotarsonemus latus* Banks (Acari: Tarsonemidae) – a serious pest on pepper in greenhouses. [*Polyphagotarsonemus latus* Banks (Acari: Tarsonemidae) – značajna štetočina paprike u zaštićenom prostoru]. Plant Doctor. [Biljni Lekar.] 38 (2): 133–138. (In Serbian).
- JEPPSON L. R., KEIFER H. H. & BAKER E. W. 1975. Mites injurious to economic plants. Berkeley: University of California Press, 614 p.
- KYPRIOTIS A., KATERINIS S., ANDREADIS S. S. & NAVROZIDIS E. 2017. Presence, description and developmental characteristics of the newly emerging quarantine pest *Aleurocanthus spiniferus* in Corfu. In: LYTRA I. & DIONYSIOS PERDIKIS D. (Eds.) Abstract book of the 17th Panhellenic Entomological Congress, Athens, Greece, p. 74.
- LIQUIDO N. J., BARR P. G. & CUNNINGHAM R. T. 1998. An encyclopedic bibliography of the host plants of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), Version 1.0 (electronic database/program). In: THOMPSON F. C. (Ed.) Fruit Fly Expert Identification System and Biosystematic Information Database. Diptera Data Dissemination Disk (CD-Rom). Nashville, TN, USA: MEDHOST.
- MASTEN MILEK T., MARKOTIĆ V., ŠIMALA M. & PINTAR M. 2017. Grey citrus scale (*Coccus pseudomagnoliarum* (Kuwana, 1914)) – economically important pest of citrus. [Siva štitasta uš agruma (*Coccus pseudomagnoliarum* (Kuwana, 1914)) – gospodarski važan štetnik agruma.] Plant Protection Bulletin [Glasilo biljne zaštite] 17 (6): 548–556. (In Croatian).
- MIJUŠKOVIĆ M. 1959. Peach fly, a new important problem of plant protection in our country. [Breskvina mušica, novi važan problem zaštite bilja kod nas.] Our Agriculture [Naša Poljoprivreda]. 5 (1): 21–30. (In Serbian).
- MIJUŠKOVIĆ M. 1973. The study of the mites on the citrus trees on the Yugoslav littoral. Final Technical Report. Titograd: Poljoprivredni Institut, 235 p.
- MIJUŠKOVIĆ M. 1999. Diseases and pests of subtropical fruits. [Bolesti i štetočine suprotropskih voćaka.] Podgorica: University of Montenegro, Biotechnical Faculty. 228 p. (In Serbian).
- MIJUŠKOVIĆ M. & TOMAŠEVIĆ B. 1975. The mites on the citrus trees on the Yugoslav littoral. [Pregljevi na agrumima na Jugoslovenskom primorju.] Book I. Titograd: Society for Science and Art of Montenegro, Department of Natural Sciences. [Knjiga I. Titograd: Društvo za nauku i umjetnost Crne Gore, Odjeljenje prirodnih nauka], 203 p. (In Serbian).
- OEPP/EPP0 2004. Normes OEPP EPP0 Standards. Good plant protection practice. Citrus. Bulletin OEPP/EPP0 34: 41–42.

- OLLITRAULT P. & NAVARRO L. 2012. Chapter 16. Citrus. In: BADENES M. L. & BYRNE D. H. (Eds.) Fruit breeding. New York: Springer, pp. 623–662.
- PETANOVIĆ R. 2004. Atlas. Harmful mites of ornamental plants. [Atlas. Štetne grinje ukrasnih biljaka]. Belgrade: Beografik, 99 p. (In Serbian).
- POLLINI A., PONTI I. & LAFFI F. 2002. Insects harmful to fruit plants. [Insetti dannosi alle piante da frutto Verona: L'Informatore Agrario Edizioni, 314 p. (In Italian)]
- PORCELLI F. 2008. First record of *Aleurocanthus spiniferus* (Homoptera: Aleyrodidae) in Apulia, Southern Italy. EPPO Bulletin 38 (3): 516–518.
- RADONJIĆ S. 2002. Citrus leafminer *Phyllocnistis citrella* Stainton (Lepidoptera, Gracillariidae, Phyllocnistinae), a new pest in Montenegro. Agriculture and Forestry [Poljoprivreda i Šumarstvo] 48 (1–2): 17–44. (In Serbian, English abstract)
- RADONJIĆ S. & HRNČIĆ S. 2003. *Aleurothrix floccosus* Mask. (Homoptera, Aleyrodidae), a new citrus pest in Montenegro. [*Aleurothrix floccosus* Mask. (Homoptera, Aleyrodidae), nova štetočina agruma u Crnoj Gori]. Agro-knowledge Journal [Agroznanje] 4 (2): 149–158. (In Serbian).
- RADONJIĆ S. 2004. Bionomics of citrus leaf miner *Phyllocnistis citrella* Stainton (Lepidoptera, Gracillariidae, Phyllocnistinae) in southern part of Montenegro. In: Proceedings of the International Society of Citriculture. Book of Papers 3: 924–932.
- RADONJIĆ S. 2007. The first record of *Tetranychus urticae* Koch. (Acarina, Tetranychidae) on citrus in Montenegro. IOBC/WPRS Bulletin 38: 245–248.
- RADONJIĆ S. & HRNČIĆ S. 2010. The broad mite *Polyphagotarsonemus latus* Banks (Acari: Tarsonemidae) on citrus nursery trees and potential threat for ornamental plants in greenhouses in Montenegro. [Široka grinja *Polyphagotarsonemus latus* Banks (Acari: Tarsonemidae) na sadnicama citrusa i potencijalna opasnost za ukrasne biljke u zaštićenom prostoru u Crnoj Gori]. Agro-knowledge Journal [Agroznanje] 11 (4): 5–11. (In Serbian, English summary).
- RADONJIĆ S., ČIZMOVIĆ M. & PEREIRA R. 2013. Population dynamics of the *Mediterranean* fruit fly in Montenegro. International Journal of Insect Science 5: 35–40.
- RADONJIĆ S. 2014a. Final report. Ministry of Science of Montenegro. Results of the Project: Pests from order Hemiptera (Aphididae, Aleyrodidae and Psyllidae) on citrus and their natural enemies in Montenegro and PR of China. University of Montenegro, Biotechnical Faculty. (In Serbian).
- RADONJIĆ S. 2014b. Report on the work of the Phytosanitary Directorate for 2014. [Izveštaj o radu Fitosanitarne uprave za 2014. godinu.] (In Serbian/ Montenegrin).
- RADULOVIĆ M. 1994. Studies of agrobiological properties of introduced orange cultivars in Montenegrin subtropical zone. [Proučavanje agrobioloških osobina introdukovanih sorti pomorandži u crnogorskoj suptropskoj zoni]. PhD Thesis. Faculty of Agriculture – Zemun, University of Belgrade. (In Serbian).
- RADONJIĆ S., HRNČIĆ S. & MALUMPHY C. 2014. First record of *Aleurocanthus spiniferus* (Quaintance) (Homoptera Aleyrodidae) in Montenegro. Redia 97: 141–145.
- RADONJIĆ S. 2017. Report on the work of the Phytosanitary Sector for 2017. Directorate for Food Safety, Veterinary and Phytosanitary Affairs. Ministry of Agriculture and Rural Development. [Izveštaj o radu fitosanitarnog sektora za 2017. godinu. Uprava za bezbjednost hrane veterinu i fitosanitarne poslove. Ministarstvo poljoprivrede i ruralnog razvoja.] (In Serbian/ Montenegrin).
- RADONJIĆ S. & HRNČIĆ S. 2017. A review of new alien arthropod pests and their Impact on agriculture crops in Montenegro. Acta Zoologica Bulgarica, Supplement 9: 203–210.
- RADONJIĆ S. 2018. Report on the work of the Phytosanitary Sector for 2018. Directorate for Food Safety, Veterinary and Phytosanitary Affairs. Ministry of Agriculture and Rural Development. [Izveštaj o radu fitosanitarnog sektora za 2018. godinu. Uprava za bezbjednost hrane veterinu i fitosanitarne poslove. Ministarstvo poljoprivrede i ruralnog razvoja. (In Serbian/ Montenegrin).
- ŠIMALA M. & MASTEN MILEK T. 2013. First record of the orange spiny whitefly, *Aleurocanthus spiniferus* Quaintance, 1903 (Hemiptera: Aleyrodidae), in Croatia. In: TRDAN S. & MAČEK J. (Eds.) Lectures and papers presented at the 11th Slovenian conference on plant protection with international participation. Ljubljana: Plant Protection Society of Slovenia, pp. 354–358.
- TOMANOVIĆ Ž. & RADONJIĆ S. 2001. Appearance of introduced parasitic wasp *Lysiphlebus testaceipes* (Cresson) (Aphidiinae, Braconidae, Hymenoptera) on the Adriatic Coast. Scientific conference 'Natural potentials of the land, continental waters and sea of Montenegro and their protection'. [Naučni skup 'Prirodni potencijali kopna, kontinentalnih voda i mora Crne Gore i njihova zaštita']. Žabljak, Book of Abstracts, p. 96.
- TSUCHIDA Y. & MASUI S. 2020. Effects of providing pollen to *Euseius sojaensis* or *Amblyseius eharai* (Acari: Phytoseiidae) on populations of the pink citrus rust mite, *Aculops pelekassi* (Acari: Eriophyidae). Applied Entomology and Zoology 55: 241–248.
- VACANTE V. & BONSIGNORE C. P. 2016. Interactions between the citrus bud mite *Aceria sheldoni* (Acari: Eriophyidae) and the lemon host tree in a Mediterranean area. Acarologia 56 (2): 167–174.
- VELIMIROVIĆ V. 1986. Scale insects (Coccoidea) on citrus fruits in the southern part of Montenegro with special reference to *Coccus pseudomagnoliarum* Kuwana, 1984. [Štitaste uši (Coccoidea) na agrumima u južnom dijelu Crne Gore sa posebnim osvrtom na *Coccus pseudomagnoliarum* Kuwana, 1984.] Agricultural Scientific Review [Poljoprivredna znanstvena smotra] 74: 287–303. (In Croatian).
- VELIMIROVIĆ V. 1988. Report on the occurrence, status, damages and measures to control quarantine, economically harmful and other plant diseases and pests in Montenegro. [Izveštaj o pojavi, stanju, štetama i mjerama suzbijanja karantinskih, ekonomski štetnih i ostalih biljnih bolesti i štetočina u Crnoj Gori.] Titograd (Podgorica): Agricultural Institute. (In Serbian)
- VELIMIROVIĆ V. 1989. Report on the occurrence, status, damages and measures to control quarantine, economically harmful and other plant diseases and pests in Montenegro. [Izveštaj o pojavi, stanju, štetama i mjerama suzbijanja karantinskih, ekonomski štetnih i ostalih biljnih bolesti i štetočina u Crnoj Gori.] Titograd (Podgorica): Agricultural Institute. (In Serbian).
- VELIMIROVIĆ V. 1990. Report on the occurrence, status, damages and measures to control quarantine, economically harmful and other plant diseases and pests in Montenegro. [Izveštaj o pojavi, stanju, štetama i mjerama suzbijanja karantinskih, ekonomski štetnih i ostalih biljnih bolesti i štetočina u Crnoj Gori.] Titograd (Podgorica): Agricultural Institute. (In Serbian).
- VELIMIROVIĆ V. 1994. Natural enemies on *Coccus pseudomagnoliarum* Kuwana in coastal part of Montenegro. Plant Protection [Zaštita Bilja]. 45 (2): 139–150. (In Serbian, English summary).
- ZHANG Z. Q. 2003. Mites of greenhouses: Identification, biology and control. Cambridge, UK: CABI Publishing, 244 p.