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The status of *Lindingaspis rossi* Maskell 1989 (Hemiptera: Diaspididae) from its unwanted introduction in Croatia to date

Status vrste *Lindingaspis rossi* Maskell 1989 (Hemiptera: Diaspididae) od njezine neželjene introducije u Hrvatsku do danas

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ABSTRACT

Lindingaspis rossi Maskell 1989 (Hemiptera, Diaspididae) is distributed worldwide and in several countries in the Mediterranean. In Croatia, the pest was first time recorded in the town of Sutivan on Brač island in 2014. However, there is a lack of information for the Mediterranean area regarding the pest's invasiveness and its economic impact on traditional crops. Surveillance activities that were conducted from 2015-2021 show that the pest is well established on the northwest part of Brač island. A total of 20 species belonging to 14 plant families were confirmed as host plants in the invaded area. The preferred host plants are *Phoenix canariensis* L. and *Olea europaea* L. and together, they account for over 65% of the total infestations followed by *Hedera helix* L., B. *capitata* M.B., *Punica granatum* L., *Laurus nobilis* L., *Buxus sempervirens* L., *Feijoa sellowiana* O.B., *Parthenocissus quinquefolia* L., *Trachycarpus fortunei* H.H.W., *Euonymus japonicus* T. *Ficus carica* L., *Vitis vinifera* L., *Pistacia terebinthus* L., *Morus alba* L., *Rubus fruticosus* L., *Juglans regia* L., *Syringa vulgaris* L., *Citrus limon* L., and *Rosa* sp. The spread of *L. rossi* from its initial outbreak in 2014 to the nearby coastal towns of Mirca and Supetar, along the same coastal road, suggests that human activity significantly contributes to its distribution. The current status of *L. rossi* in Croatia is established in a restricted area of Brač island.

Keywords: Black araucaria scale, Brač island, host plants, restricted area

SAŽETAK

Lindingaspis rossi Maskell 1989 (Hemiptera, Diaspididae) je proširena širom svijeta i u nekoliko zemalja Sredozemlja. U Hrvatskoj je štetnik prvi put zabilježen na otoku Braču u 2014. godini. Za područje Sredozemlja, još uvijek je nedostatak informacija o invazivnosti i ekonomskom značaju ove vrste u odnosu na tradicionalne kulture. Aktivnosti nadzora koje su provedene u razdoblju od 2015. – 2021. godine pokazale su da je štetnik udomaćen na sjeverozapadnoj strani otoka Brača. Ukupno 20 biljnih vrsta koje pripadaju u 14 biljnih porodica su potvrđene kao biljke domaćini u zaraženom području. Preferirane biljke domaćini su *Phoenix canarienssis* L. i *Olea europaea* L. koje čine preko 65% od ukupnog broja zaraženih biljki domaćina, a nadalje *Hedera helix* L., B. *capitata* M.B., *Punica granatum* L., *Laurus nobilis* L., *Buxus sempervirens* L., *Feijoa sellowiana* O.B., *Parthenocissus quinquefolia* L., *Trachycarpus fortunei* H.H.W., *Euonymus japonicus* T. *Ficus carica* L., *Vitis vinifera* L., *Pistacia terebinthus* L., *Morus alba* L., *Rubus fruticosus* L., *Juglans regia* L., *Syringa vulgaris* L., *Citrus limon* L., i *Rosa* sp. . *L. rossi* se proširila od vremena prve detekcije štetnika u 2014. godini u pravcima najbližih obalnih mjesta (Mirca i Supetar) koji su smješteni na istoj obalnoj cesti što potvrđuju da da ljudska aktivnost značajno pridonosi širenju štetnika. Trenutni status *L. rossi* u Hrvatskoj je udomaćena na ograničenom području otoka Brača.

Ključne riječi: biljke domaćini, Brač, Crna štitasta uš araukarije, ograničeno područje

INTRODUCTION

Origin and status

There is very little information about the history of the genus *Lindingaspis*. The genus *Lindingaspis* represents an important group of the Diaspididae, and the first mention of its synonym dates back to 1921 when MacGillivray identified the species *Melanaspis samoana* L. In 1937 Lindiger listed the genus *Lindingaspis* as a synonym of the genus *Melanaspis*, and newly described species were added to the genus *Lindingaspis* (McKenzie, 1943; McKenzie, 1950). *Lindingaspis rossi* Maskell 1989 is now a cosmopolitan species, it has been recorded in six biogeographical regions of the world, excluding the oceanic and Antarctic regions (Williams, 1963; Wappler et al., 2007; Ghahari et al., 2011). Table 1 presents data about known *L. rossi* world distribution including confirmed hosts.

Morphology and identification

The shield of an adult female is round, 2-2.5 mm in diameter, flattened, dark brown to black, often with concentric rings, and its color varies from light brown, grey to white (Masten Milek et al., 2015). The wax (exuvium) is located almost in the center. It is dark brown in color and has concentric circles of white wax. The first coat usually has a white wax nipple located in the centre. The body of an adult female is round in shape, transparent or pinkish in color and darkens with age. The shield of the male is similar in color to that of the female, it is round and its fur is almost in the middle (Gill, 1997). In nature, *L. rossi* can be easily confused with species of armoured scales from the genus *Chrysomphalus* Ashmead, 1880. mainly because of the similar body shape, arrangement of the lobes and organization of the plates. Microscopically, *L. rossi* differs from *Chrysomphalus* sp. Having a series of marginal micro ducts from the eye to the pygidium and a series of paraphyses connected to the fourth marginal projection. The species of the genus *Chrysomphalus* do not have these morphological characteristics (Masten Milek et al., 2015).

Biology and ecology

The biology of the species has not yet been sufficiently investigated. The individuals feed on leaves and needles as well as fruit, as is the case with olives (*O. europaea* L.) (Noyes and Valentine, 1989; Charles and Henderson, 2002) and apples (*M. domestica* L.) (Timlin, 1964). Two relevant references give information on one generation per year on the California pine (*P. radiata* L.) in New Zealand (Timlin, 1964), while in Egypt the species can have more than three generations per year (Swailem et al., 1980). Females lay their eggs in September and October, and larval emergence has been recorded as early as November (Timlin, 1964). Swailem et al. (1980) recorded two or three peaks in the number of individuals on an annual level, on different hosts in Egypt. It is likely that these peaks are correlated with the number of generations. The number of generations a species reaches per year may be related to climatic conditions. For example, a species in Egypt, which is located in a subtropical area whose climate is characterized by hot summers and warm winters where the temperature reaches 23 °C in January, reaches three generations per year (Agrawala et al., 2004). Considering the above, we can assume that the species can achieve a greater number of generations under warmer conditions which still need to be clarified. Considering that most species of the genus *Lindingaspis* are of Afrotropical origin, the difference in reaching the maximum number of populations throughout the year is also evident. The species is also widespread in other parts of the world where conditions are somewhat less favorable for its development. The available literature shows that the species manages to maintain itself but with a visible difference in the realization of its potential. It is most commonly found on adventive plants, as well as other species of the Diaspididae family (Harris et al., 2007), but also infests native species of a particular area (Henderson, 2011). The species is highly polyphagous and infests a very diverse and large number of plant species (Masten Milek et al., 2015), mainly ornamental plants and some fruit species. Borchsenius (1966) recorded hosts from 62 families.

Table 1. Geographic distribution and confirmed host plants of *Lindingaspis rossi*

Country/location	Confirmed hosts	Reference
Australian region		
New Zealand	*Citrus* sp. (Rutaceae)	Cottier, 1938; Henderson, 2011
New Zealand	*Malus domestica* L. (Rosaceae)	Timlin, 1964; Henderson, 2011
New Zealand: Whangarei	*Olea europaea* L. (Oleaceae)	Noyes and Valentine, 1989; Charles and Henderson, 2002; Henderson, 2011
Australia: Adelaide, Melbourne, Sydney	*Abutilon* sp. (Malvaceae)	McKenzie, 1950
	Artemisia sp. (Asteraceae)	
	Coccoloba sp. (Polygonaceae)	
	Eucalyptus sp. (Myrtaceae)	
	Hyssopus sp. (Lamiaceae)	
	Oleander sp. (Apocynaceae)	
	Riccinocarpus sp. (Ricciaceae)	
	Xanthorrhoea sp. (Xanthorrhoeoideae)	
	Leucadendron sp. (Proteaceae)	Suh et al., 2013
Australia: Northeastern Victoria	*Pinus radiata* D. (Pinaceae)	Minko, 1961
Australia	*Malus domestica* L. (Rosaceae)	Timlin, 1964; Spooner-Hart et al., 2007
	Olea europaea L. (Oleaceae)	
	Citrus sp. (Rutaceae)	
Australia: Tasmania	*Arbutus unedo* L. (Ericaceae)	Hudson, 1967
	Camellia japonica L.(Theaceae)	
	Cotoneaster sp. (Rosaceae)	
	Euonymus sp. (Celastraceae)	
Nearctic region		
USA: Hawaii	*Araucaria* sp. (Araucariaceae)	Miller et al., 2005
USA: California	*Eucalyptus* sp. (Myrtaceae)	Miller et al., 2005
	Sequoia sempervirens (D.Don) Endl.) (Cupressaceae)	
	Aaraucaria sp. (Araucariaceae)	

Continued. Table 1

Country/location	Confirmed hosts	Reference
USA: San Miguel Islands	*Acacia melanoxylon* C. (Fabaceae)	Ben-Dov et al., 2012
USA: Los Angeles, San Diego, Santa Barbara, Ventura	*Citrus sinensis* O. (Rutaceae)	McKenzie, 1956
	Olea europaea L. (Oleaceae)	
	Hedera helix L. (Araliaceae)	
	Camellia japonica L. (Theaceae)	
	Eucalyptus sp. (Myrtaceae)	
Oriental region		
Thailand: Chicken Island	*Meryta sinclairii* S. (Araliaceae)	Beever, 1984
Neotropical region		
Argentina: Buenos Aires	*Callistemon speciosus* S. (Myrtaceae)	González and Charlin, 1968; Zamudio and Claps, 2005
	Olea europaea L. (Oleaceae)	
	Araucaria angustifolia K. (Araucariaceae)	
Cille: Santiago	*Callistemon speciosus* S. (Myrtaceae)	González and Charlin, 1968; Zamudio and Claps, 2005
	Olea europaea L. (Oleaceae)	
	Araucaria angustifolia K.	
Afrotropical region		
South Africa	*Olea europaea* L. (Oleaceae)	Costa, 2007
	Phoenix canariensis C. (Arecaceae)	Quednan, 1964
	Hedera helix L. (Araliaceae)	Annecke and Mynhardt, 1970
Cape Town Stellenbosch Citrusdal	*Malus domestica* L. (Rosaceae)	Rosen and DeBach, 1979; Prinsloo and Neser 1994
	Citrus sp. (Rutaceae)	
Ehypt: Giza, Zagazig	*Pinus radiata* D. (Pinaceae)	Swailem et al., 1980; Watson et al., 2002; Badr, 2014
Spain: Canary Islands	*Phoenix canariensis* C. (Arecaceae)	Gómez-Menor Ortega, 1954; Granara De Willink and Claps, 2003
Palearctic region		
Korea	*Leucadendron* sp. (Proteaceae)	Suh et al., 2013
France	*Olea europaea* L. (Oleaceae)	Danzig and Pellizzari, 1998; Germain, 2007

Continued. Table 1

Country/location	Confirmed hosts	Reference
Italy: Sicily	*No data about hosts*	Longo et al., 1995.
Portugal: Ponta Delgada	*No data about hosts*	Balachowsky, 1938; Ben-Dov and Sánchez-Garsia, 2015
Monaco	*No data about hosts*	Nakahara, 1982
Croatia	*Phoenix canariensis* C. (Arecaceae)	Masten Milek et al., 2015
	Olea europaea L. (Oleaceae)	
	Butia capitata M.B. (Arecaceae)	

It is most commonly found on the leaves of plants (Evans et al., 2009), while Balachowsky (1956) states that in the Mediterranean region this species is most commonly found in gardens. *L. rossi* can actively spread as a first-instar larva, as it only has functional legs in the first instar. However, the individual is not able to travel long distances with these legs alone. In this case, humans, animals and various abiotic factors, usually the wind, contribute to the spread. Adults and eggs can only be transmitted through trade or transportation of infected plant material (Masten Milek et al., 2015), and in such cases, the species can produce a very large number of new individuals in the population, which can cause considerable damage. The known natural enemies of *L. rossi* are the parasitic wasps *Aphytis chrysomphali* Mercet, 1912 and *Encarsia citrina* (Hymnoptera, Aphelinidae) (Masten Milek et al., 2015). The aim of this research is to show the historical spread of *L. rossi* on the island of Brač with a presentation of the confirmed host plants and to give an overview of the available measures to prevent the pest from further spreading and control.

MATERIALS AND METHODS

Visual inspections and sampling

During the periods: June – August 2015, June – August 2017, August 2019 and June – August 2021, the town of Supetar and all municipalities on island Brač, Croatia (Figure 1), namely: Sutivan (43°23'00.2"N 16°28'21.8"E), Milna (43°20'09.0"N 16°27'02.5"E), Nerežišća (43°19'42.9"N 16°34'17.9"E), Pučišća (43°20'37.9"N 16°44'15.7"), Postira (43°22'28.7"N 16°37'42.0"E), Bol (43°15'46.8"N 16°39'05.1"E) and Selca (43°17'25.9"N 16°50'42.5"E), were surveyed for the presence of *L. rossi*. Known host plants of *L. rossi* were examined in various locations for the presence of *L. rossi* stages. Visual inspections and observation were conducted in orchards, private and urban gardens, ornamental tree-lined streets, park areas, natural reserves and in orchards and vineyards. Visual inspection activity includes observation of the whole plant from the lateral sides and inside the canopy. Inspection activities started in the centre of the cities, following the first founding in the city of Sutivan in 2014 and then extended along the main roads and orchard/vineyard routes looking for infested host plant species. Visual inspection and collection of the samples were conducted during the June-August period while inspection and sampling of the decidious host plants were conducted during August. In the case of leaf sampling, four to six branches containing leaves or individual leaves were cut with garden shears. Fruits were picked with garden shears individually or together with the branch. Samples of branches with leaves and fruits containing any of stage of *L. rossi* were stored in the plastic zip bag, marked with collection data, stored in the portable refrigerator. Pictures of infestation on each host plant and notes were taken on the detection sites.

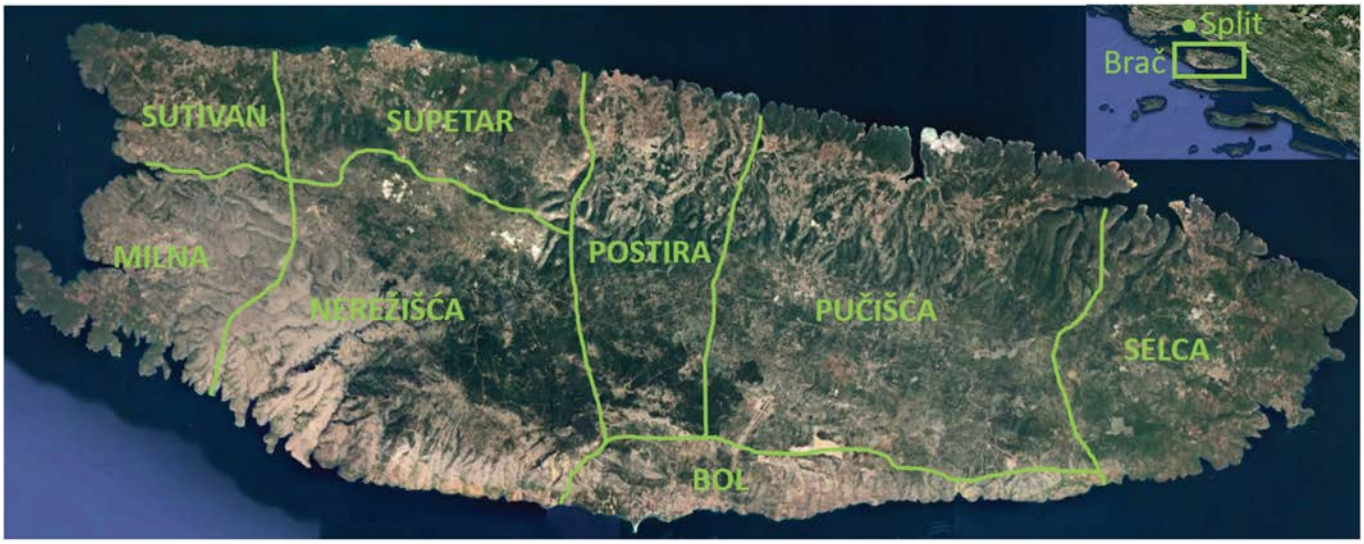

Figure 1. Administrative – territorial units of island Brač surveyed for the presence of *L. rossi*

Identification

Specimens were collected and stored using wet and dry storage methods (McKenzie, 1956; Wilkey, 1990; Gill,1997; Miller and Davidson, 2005). The collected samples were processed at the Laboratory of Entomology, Plant Protection Institute, Zagreb (Croatia), and the Department for Mediterranean Crop Protection in Solin (Croatia). Adult females are the basis for the morphological identification of the species. The samples were kept at room temperature until examination, considering that they were examined the day after taking the samples due to the accuracy of the examination results. The microscopic permanent preparations and identification based on the morphological characteristics of the females were conducted according to McKenzie (1950), Williams (1963), Williams and Watson (1988), Gill (1997) and Miller and Davidson (2005). An Olympus BX 51 and Olympus SZX7 light microscope with magnifications of 10x, 20x, 40x and 100x, eyepieces with WHSZ magnification of 10x was used for identification.

RESULTS AND DISCUSSION

Historical overview of invasion and current distribution

2015: A survey that was conducted during 2015 confirms spreading of *L. rossi* in the very nearness area of 200 meters radius in the immediate vicinity of the first discovery in the public center of the town of Sutivan. In 2015, the pest was recorded on *P. canariensis* and *O. europaea* so far confirmed host plants.

2017: Further spread along the territory of the town of Sutivan was recorded and an outbreak of *L. rossi* was recorded in the village of Mirca. The area of approximately 120 ha of the town of Sutivan was inspected. This area is characterised by the public areas, private houses with gardens or backyards where numerous and different types of fruit and ornamental plants are planted. Furthermore, the marginal border of the town, orchards and natural vegetation of Mediterranean maquis were visually inspected. This survey shows that about 50 ha of the area of town of Sutivan was invaded by *L. rossi* in relatively short period of time. Beside spreading of the pest along the area of the town of Sutivan, an outbreak of *L. rossi* was recorded in the village of Mirca belonging to the administrative area of the town of Supetar. The Mirca location is situated on the state road 4,9 km east of the town of Sutivan. The outbreak in Mirca was related to the single plant of *P. canariensis* tree in the centre of the village.

2019: Further spread of the pest in the urban area west of the town of Sutivan and around the first detection area in the village of Mirca. A new outbreak was recorded

in the tourist settlement in the town of Supetar on several olive *O. europaea* trees in touristic resort. The town of Supetar is situated 2,8 km from Mirca and 6,6 km from town of Sutivan.

2021: Further spread of the pest in the town of Supetar has taken on a larger scale because the pest was observed along a larger part of the urban area with mostly private houses with gardens where different types of plants grow. An identical scenario was observed in 2021 in the area west of Sutivan.

The current known distribution of *L. rossi* is presented in Figure 2 showing that the pest is present on the north-west part of Brač island. From the first record in the town of Sutivan in 2014 till 2021, the pest spread along north-west part of Brač island and invaded the area of the village of Mirca and town of Supetar.

Host plants and their importance

After the first detection of *L. rossi* in the center of the city of Sutivan in 2014, when the infestation was recorded on several plants of *P. canariensis*, *Butia capitata* Mart. Becc. and *O. europaea*, (Masten Milek et al., 2015) severe infestation was also recorded during the 2015 survey. The infestation of *P. canariensis* trees was estimated at several thousand specimens of adults and larvae per leaf attached to the upper surface (Figure 3) on over fifteen trees in the public park of Sutivan. The infestation of two *O. europaea* trees adjacent to *P. canariensis* trees was also significant, and adults and larvae were widely distributed throughout the canopy, both on leaves and fruit (Figure 4). Infestations on leaves ranged from 20 to over 50 individuals per leaf (Figure 5), depending on the age of the leaves (lower numbers of adults on older leaves and higher numbers of larvae and newly developed adults on younger leaves). The infestation of *O. europaea* fruits ranged from a few to almost a hundred specimens per single fruit (Figure 6). Regarding the infestation of *O. europaea*, the active dispersal of first instar larvae from leaves to fruits is evident due to the annual fruit set phenology. Young *L. rossi* larvae were observed migrating on fruits from late June with an increase in the number of larvae per fruit during July and their development into adults during August 2015.The active dispersal of first instar larvae and heavy infestations are therefore indicative of these evergreen host plants.

During the 2017 survey, 11 additional host plants of *L. rossi* were observed. Infection with different numbers of *L. rossi* stages was recorded on both leaves and fruits of traditional fruit species of economic importance. Those findings refer to *Ficus carica* L. and *Punica granatum* L.. *L. rossi* heavily infested leaves and vegetative leaf bud of *F. carica* and less on the fruits (Figures 7 and 8).

Figure 2. Historical spreading of *L. rossi* over northeast coastal area of Sutivan municipality and city of Supetar (Green line represents the administrative border between Sutivan municipality and the town of Supetar)

Figure 3. Infested *Phoenix canariensis*
(Photo by Mario Bjeliš)

Figure 4. Infestation on *Olea europaea*
(Photo by Mario Bjeliš)

Figure 5. Infested *O. europaea* leaves
(Photo by Mario Bjeliš)

Figure 6. Infested *O. europaea* fruits
(Photo by Mario Bjeliš)

Figure 7. Infestation on *F. carica* leaves
(Photo by Mario Bjeliš)

Figure 8. Infestation on *F. carica* fruits
(Photo by Mario Bjeliš)

Infested *P. granatum* leaves look completely exhausted when up to 20 individuals were recorded on the upper side of the leaves, looking almost on the verge of dying, possibly because of the thin leaves while few individuals are recorded on the fruits (Figures 9 and 10). *J. regia* leaves were heavily infested containing hundreds of individuals on the leaf surface but no infestation was found on walnut fruits (Figure 11). Different stages of *L. rossi* were observed also on several wild fruit species like *Rubus fruticosus* A. (Figure 12), *Morus alba* L. (Figure 13) and *Pistacia terebinthus* L. (Figure 14) followed by *Vitis vinefera* L. (Figure 11) and *Parthenocissus quinquefolia* L. (Figure 15). Infestation with *L. rossi* has also been observed on evergreen woody plants, partly in the Mediterranean maquis, as in the case of *P. terebinthus* (Figure 14), *H. helix*, (Figure 17 and 18), *L. nobilis* L. (Figure 19) and *Euonymus japonicus* Thunb. (Figure 20).

Surveys carried out in 2019 confirmed that in the cases of both the village of Mirca and the town of Sutivan, *P. canariensis* and *O. europaea* were recorded as new founded host plants. In the town of Supetar which is adorned with numerous *O. europaea* trees along the sidewalks, streets and residential buildings a very small number of *L. rossi* individuals were found on almost each *O. europaea* tree.

The 2021 survey shows that the spread of the pest in the town of Supetar has taken on a larger scale because the pest is spreading to a larger part of the urban area with mostly private houses with gardens where different types of plants grow, aimed at renting out for tourist purposes. An identical scenario was observed in 2021 in the area west of Sutivan. Beside infested *P. canariensis* and *O. europaea* trees, 5 additional host plants of *L. rossi* were recorded. A few potted plants of *Trachycarpus fortunei* (Hook.) H. Wendl., *Syringa vulgaris* L., *Buxus sempervirens* L., *Citrus limon* L. and *Rosa* sp. Were also found to be infested with *L. rossi* individuals. The results of the surveys carried out at intervals of several years show that *L. rossi* has spread from the first outbreak in Sutivan in 2014 to the two nearest coastal towns on the same road. In all three outbreaks (Sutivan, Mirca and Supetar), *P. canariensis* and *O. europaea* were detected as the first infested host plants, followed by local spread to other host plants. A total of 20 plant species belonging to 14 plant families were confirmed as a host plants of *L. rossi* (Table 2).

Figure 9. Infested *P. granatum* leaves
(Photo by Mario Bjeliš)

Figure 10. Infestation on *P. granatum* fruits
(Photo by Mario Bjeliš)

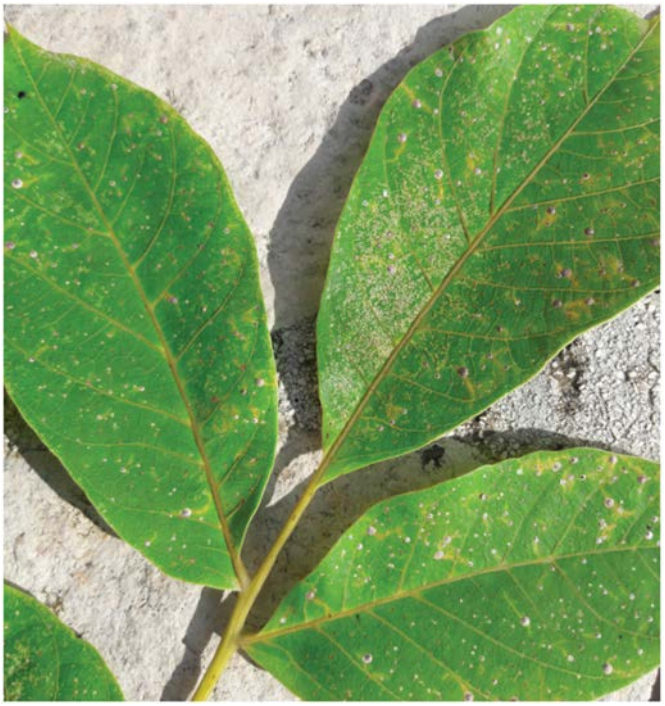

Figure 11. Infestation on *J. regia* leaves
(Photo by Mario Bjeliš)

Figure 12. Infestation on *R. fruticosus* leaves
(Photo by Mario Bjeliš)

Figure 13. Infested *M. alba* leaves
(Photo by Mario Bjeliš)

Figure 14. Infested *P. terebinthus* leaves
(Photo by Mario Bjeliš)

Figure 15. Infested *V. vinifera* leaves
(Photo by Mario Bjeliš)

Figure 16. Infestation on *P. quinquefolia* leaves
(Photo by Mario Bjeliš)

Figure 17. Infested *H. helix* leaves
(Photo by Mario Bjeliš)

Figure 18. Severe infestation on *H. helix*
(Photo by Mario Bjeliš)

From the data collected, *P. canariensis* and *O. europaea* are the most numerous and preferred host plants, accounting for over 65% of the total number of infested plants, followed by *H. helix* and other host plants (Figure 21).

In contrast, few isolated individuals of the pest have been found on *L. nobilis* and more on *Euonymus japonicus* Thunb.

Figure 19. Infestation on *L. nobilis*
(Photo by Mario Bjeliš)

Figure 20. Infested *E. japonicus*
(Photo by Mario Bjeliš)

Table 2. Confirmed host plants of *Lindingaspis rossi* on the Brač island survey from 2015-2021

Plant family by alphabetic order	Species
Anacardiaceae	*Pistacia terebinthus* L.
Araliaceae	*Hedera helix* L.
Arecaceae	*Phoenix canariensis* C.
	Trachycarpus fortunei (Hook.) H. Wendl.
	Butia capitata Mart. Becc.
Buxaceae	*Buxus sempervirens* L.
Celastraceae	*Euonymus japonicus* Thunb.
Juglandaceae	*Juglans regia* L.
Laureaceae	*Laurus nobilis* L.
Lythraceae	*Punica granatum* L.
Moraceae	*Ficus carica* L.
	Morus alba L.
Myrtaceaea	*Feijoa sellowiana* O.B.
Oleaceae	*Olea europea* L.
	Syringa vulgaris L.
Rosaceae	*Rosa* sp.
	Rubus fruticosus A.
Rutaceaea	*Citrus limon* L.
Vitaceae	*Vitis vinifera* L.
	Parthenocissus quinquefolia L.

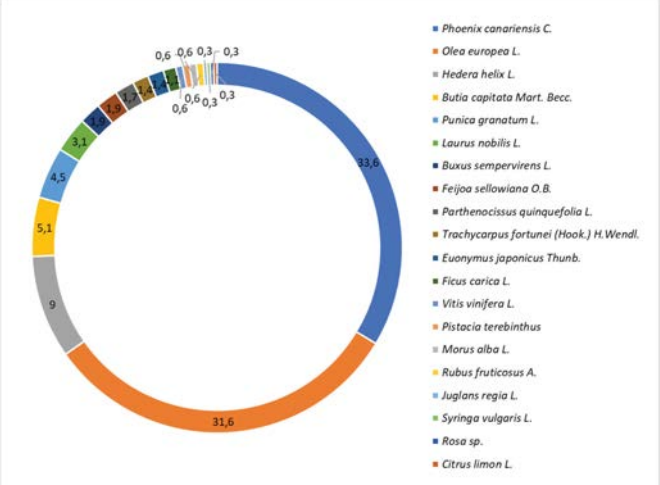

Figure 21. The share of host plants on which *L. rossi* infestation was detected during the surveillance carried out in the period from 2015 to 2021

Current status and control strategies

L. rossi became established in the town of Sutivan shortly after its introduction, from where it spread to new neighbouring areas. Due to the traditional olive cultivation on Brač island, the occurrence of *L. rossi* is considered a serious phytosanitary and economic problem (Masten Milek et al., 2015; Masten Milek et al., 2017). The presence of larvae on the fruit is a major problem in the production of green table olives for preservation. The question of the acceptability of processing fruit with varying degrees of contamination for the production of olive oil also remains open (Bjeliš et al., 2015, 2018).

It must be emphasised that in all cases where *L. rossi* was detected during 2015-2021 one or two *P. canariensis* trees followed by *O. europaea* were the main source of the infestation, from which pest spread to various surrounding plant species. This observation is confirmed by numerous findings during the survey which stands for the importance of *P. canariensis* (Quednan, 1964; Granara De Willink and Claps, 2003; Masten Milek et al., 2015) and *O. europaea* (González and Charlin, 1968; Noyes and Valentine, 1989; Charles and Henderson, 2002; Zamudio and Claps, 2005; Spooner-Hart et al., 2007; Masten Milek et al., 2015) as a very sensitive and attractive host of *L. rossi*. This is supported with scenario from outbreak in Supetar, the town which is adorned with numerous *O. europaea* trees along the sidewalks, streets and residential buildings. In this area, a very small number of *L. rossi* individuals were found on almost each of the nearly fifty olive trees, on leaves and fruits. Infestation with *L. rossi* has also been observed on evergreen woody plants in the Mediterranean maquis, as in the case of *P. terebinthus* and *H. helix*. Those 2 due to the number of infected plants in the surveyed area suggest that are certainly additional reservoirs for the conservation of the species *L. rossi* and hot spots from which the pest spreads continuously in various ways. Several host plants belong to the deciduous trees in which a very high intensity of infection was observed at the same time. This reffer to

F. carica, *P. granatum*, *J. regia*, *R. fruticosus*, *V. vinifera*, *P. quinquefolia* L. and *M. alba* L. These examples are a clear proof of the dispersal of *L. rossi* larvae by the wind. No immobile stages were found on bark, twigs or other woody plant parts of the hots listed above during the survey activities. This suggests that with the emergence of the first larval generation from overwintering adults on the main evergreen hosts (*P. canariensis*, *O. europaea*, *P. terebinthus* and *H. helix*), wind dispersal on deciduous plant species over longer distances is an important dispersal tool.

Bjeliš et al. (2018) emphasize the unexpected and rapid spread of *L. rossi* in the Sutivan area and the strong establishment of the species. They recommend that in case of failure to implement organized measures to prevent the spread and control, the further spread of the pest poses the risk of the pest entering the olive groves and becoming domesticated. Bjeliš et al. (2018) and Ivić et al. (2022) make suggestions for the strategy of combining the control of the main olive pests with the control of *L. rossi*. Research dealing with suppression strategy and effective control of *L. rossi* species is very limited worldwide same as data regarding the efficacy of acceptable and registered insecticides. Literature data reported the need to control this species on olives in Australia (Spooner-Hart, et al., 2007) and in the Republic of South Africa (Costa, 2007) and on roses (Srinivasan et al., 1974). Preliminary data on the insecticide efficacy for *L. rossi* control include recommendations to use *parafin oil*, *rapesead oil*, and *avermectin* ranging from 52,23% to 86,62% efficacy (Bjeliš et al., 2015) on *O. europaea* larvae. Jakovljević et al. (2020) and Ivić et al. (2022) give recommendations for the use of various insecticides based on *parafin oil*, *pyriproxifen* and *fosmet*.

Since 2022, *L. rossi* become a regulated pest in the Republic of Croatia after an official suppression regulation on measures to prevent the spread and control of *L. rossi* has been in force (Narodne Novine, 2022). This regulation is in line with the EU Regulation of the European Parliament on protective measures against harmful organisms for plants and amending Regulation (EU) no. 228/2013, (EU) no. 652/2014 and (EU) no. 1143/2014 of the European Parliament and the Council (Narodne Novine, 2022). The purpose of the regulation is to define the measures that need to be taken to prevent the further spread of *L. rossi* and to conduct suppression measures. The regulation prescribes measures to prevent the spread and control of *L. rossi*, explains the infested sub-area, the host plants, the monitoring program and the obligations of plant owners. Prevention and control measures include mechanical removal of infected plant parts, and chemical or biological treatment on host plants of economic importance and other host plants. Host plants of economic importance in the sense of official regulation are: *O. europaea*, *V. vinifera*, *F. carica*, *P. granatum*, *Citrus* spp., *P. canariensis* and *B. capitata*.

Other host plants in the sense of the official regulation are *H. helix*, *L. nobilis*, *E. japonicus* etc. and all other wild and ornamental plants on which the *L. rossi* is recorded. If the control measures are not justified or feasible, the other host plants must be completely removed in such a way as to achieve the destruction of *L. rossi* and prevent its further spread. The official survey program is adopted on a yearly base by NPPO which determines the presence, spread and height of the population of *L. rossi*. Costs for the implementation of the measures prescribed in official regulation are provided in the state budget of the Republic of Croatia for the purposes of co-financing the implementation of the measures and as part of the implementation of emergency phytosanitary measures (Narodne Novine, 2022).

CONCLUSIONS

The status of *Lindingaspis rossi* Maskell 1989 (Hemiptera, Diaspididae) in Croatia is regulated pest that is established on a restricted area of Brač island. Human activity and spreading by wind significantly contribute to the spread of the pest. Numerous host plants and ways of spreading represents risk of the further spread and establishment of the pest to other municipalities on the Brač island. I suggest rephrasing: Therefore, measures to prevent the spread and to suppress *L. rossi* are defined through official regulations and are coordinated by the NPPO of the Republic of Croatia.

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