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A Report of Alien Species *Icerya purchasi* Maskell, as Pest of *Rosmarinus officinalis* Linné in Romania

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Abstract: *Icerya purchasi* Maskell (Hemiptera: Monophlebidae), the cottony cushion scale is an invasive pest well known for its polyphagy which has preference for woody plants as many perennial ornamental shrubs and trees, also fruit and forest trees. The insect is recorded on many plant species belonging to more than 80 families, especially on *Citrus* spp. and many ornamentals. The damages produced by this scale has economic importance, sometimes the destroying entire orchards. The research concerning the record and identification of cottony cushion scale were carried out in spring of 2022 in Cluj-Napoca (Romania). The insects have been observed on *Rosmarinus officinalis* Linné and than collected, identfieded, prepared and photographed with the corresponding description.

Keywords: alien species, *Icerya purchasi* Maskell, *Rosmarinus officinalis* Linné.

Introduction

Invasive alien species introductions are driven primarily by global trade, transport and tourism. The spread of many invasive insect species is caused by international trade through the movement of plant material (whole plants, saplings, cuttings, seedlings, bulbs, tubers, runners, seeds, etc.) and is a very important problem.

Hulme (2021) shows that trade in live plants and agricultural products has often been signaled as one of the most important introduction pathways and in these particular circumstances, it makes sense to focus on the primary commodities (e.g., live plants) that are most likely to be associated with the introduction of specific groups of alien species of interest (e.g., phytophagous insects).

Icerya purchasi Maskell (Hemiptera: Monophlebidae), the cottony cushion scale or citrus fluted scale, is an invasive pest well known for its polyphagy which has preference for woody plants as many perennial ornamental shrubs and trees, also fruit and forest trees. The insect is recorded on many plant species belonging to more than 80 families, especially on *Citrus* spp. and many ornamentals. The damages produced by this scale has economic importance, sometimes the destroying entire orchards (en. wikipedia. org/).

Taxonomy

Icerya purchasi Maskell (1879) belongs to the large scale insect family Monophlebidae and the genus *Icerya* has not been studied in depth.

The insect was described for the first time in 1878 and named by William Miles Maskell, from some specimens collected from *Acacia ornata* (kangaroo acacia) by Dr. Purchas in Auckland (New Zealand) (Morales, 1991).

Distribution

The origin of *Icerya purchasi* Maskell, the cottony cushion scale is on the australian continent. It has a wide climatic tolerance and has become established as a pest in southern Europe. It's usually found indoors in colder regions (Kondo and Watson, 2022).

According to GISD (Global Invasive Species Database www.iucngisd.org) and CABI ISC (Invasive Species Compendium www.cabi.org/isc), this polyphagous invasive pest is worldwide distributed, throughout the tropical and warmer temperate regions, especially in the citrus growing area.

The geographic distribution of *Icerya purchasi* Maskell, the cottony cushion scale include 148 countries (scalenet.info).

Climate change models for future show that environmental changings will increase the geographic expansion for this pest and South America, Asia, Europe would be more suitable for *Icerya purchasi* Maskell (Liu and Shi, 2020).

History of Introduction and Spread

This scale was accidentally introduced from Australia to California in 1868-1869 in a nursery free shipment and become a major pest of citrus trees. By 1887 threatened to destroy the citrus industry in Southern California. The citrus growers were so desperate to control the pest so that they used cyanide fumigation and burning

their orchards, but without long-term success. The problem was solved by Charles V. Riley who was later responsible for the first successful large-scale biological control project against the cottony cushion scale, *Icerya purchasi* Maskell, using two natural enemies imported from Australia, that had the potential to serve as effective biocontrol agents in the U.S. In 1888, Riley and his colleagues, released a parasitoid fly species, *Cryptochaetum iceryae* Willinston and the australian vedalia beetle, *Novius* (sin. *Rodolia*) *cardinalis* Mulsant, in San Mateo County (California). By the end of 1889, the cottony cushion scale population had already declined, being completely controlled (Quezada and DeBach, 1973; DeBach, 1974; Caltagirone and Doutt, 1989; Borowy and Pieper, 2021; Kernan, 2022).

The pest has spread widely through most of the tropical and subtropical countries of the world. Over the next century, *Icerya* spread around the Globe—to Middle East, France, Italy, Greece, Eastern Europe, Crimeea, South Africa, India, Korea, Japan, Peru, Chile, the Galápagos Islands and elsewhere (Ormerod, 1887; Marin-Loayza, 1990; Mathews et al., 2001; Varshney, 2005; Hasani and Alikaj, 2011; Kim et al., 2011; Papadopoulou and Chryssohoides, 2012; Kollár et al., 2016; Sharmagiy et al., 2021; Kernan, 2022).

Morphology

The adult female (hermaphrodite) of *Icerya purchasi* Maskell has an oval body of about 5-10 mm long, red-brown or dark-red, covered of dorsal white waxy secretion with medial ridge of wax and segmental waxy tufts projecting from ventral margin around body. From the margins of the body there are projected glassy filaments. The anntenae (9-11 articles), legs and body hairs are black. Spines are absent. The derm hairs and setae varying in abundance, size and shape. In the end of body, the female has attached an ovisac with a characteristic striation, made by uniform ridges over the surface. The ovisac may reach the body length and is a long waxy-fibered substance resembling cotton. It is extruded from glands at the rear of the abdomen to protect newly laid eggs (Morales, 1991; Grafton-Cardwell, 2002; Hamon and Fasulo, 2005; Unruh and Gullan, 2008; Hasani and Alikaj, 2011; Weeks et al., 2012; Zuehlke and Lefevre, 2020; Kondo and Watson, 2022; www.citscihub.nz).

The adult male is rare observed and has a short life. He is about 0,3-0,5 cm long with a dark red body, dark colored antennae and legs, shiny, black, diamond-shaped patch on top of middle body

segment (thorax). Antennae are long with 10 articles and thin with tiny whorls of hair-like setae surrounding each antennal article, except the basal one. Gnat-like appearance, slow moving and has a pair of well-developed and functional wings, dark brown with a red vein branching once into two smaller veins (Quezada and DeBach, 1973; Weeks et al., 2012).

Eggs are oval, elongated and smooth, 0,65x0,3 mm on average. During incubation, inside the egg shell, they become darker (Marin-Loayza, 1990).

First instar larva is elongated oval shape, reddish in colour, covered with white wax, 0,8-1,1 mm long, 0,5-0,8 mm width with black antennae, legs and with 3 pairs of long setae at tip of abdomen (Marin-Loayza, 1990; Morales, 1991; Hasani and Alikaj, 2011).

Second instar larva is reddish-brown-orange on ventral side, 1,4 mm long (Marin-Loayza, 1990; Hasani and Alikaj, 2011).

Third instar larva is reddish-brown with a 2,2x1,2 mm oval groove covered with powdery yellow wax, which lasts until the next molting (Marin-Loayza, 1990; Hasani and Alikaj, 2011).

It is interesting that the female is always a hermaphrodite with both testes and ovaries. If self-fertilization occurs only hermaphrodites are produced; however, when a hermaphrodite mates with a male, more males and hermaphrodites are produced (Ebeling, 1959).

Biology and Ecology

The adult of *Icerya purchasi* Maskell is a functional hermaphrodite which has both male and female reproductive organs and is capable of self-fertilization (Kondo and Watson, 2022). However the “females” are actually hermaphrodites with fertilization occurring between the eggs and the sperm of the same individual (Morales, 1991). Yet physical observation and genetic data reveal that males occasionally mate with hermaphrodites and wild hermaphrodites occasionally outcross, thus preventing a complete loss of genetic variation (Mongue et al., 2021). Sexually functional males are occasionally produced from unfertilized eggs, but mating is not necessary for reproduction (Morales, 1991).

Parthenogenesis is unknown in this species. There are 2-4 overlapping generations per year. Depending on body size, condition of the host and climatic conditions, the hermaphroditic adult produce 250-2000 eggs over a period of 2-3 months into the ovisac, continuously secreted from the venter of the adult's abdomen.

Hermaphrodites produce hermaphrodite progeny, or hermaphrodites and a very small proportion of males. Females that have to mate with males to produce offspring are unknown. First-instar crawlers hatch from the eggs and emerge from the ovisac (Kondo and Watson, 2022). After leaving the egg sac, the crawlers settle along the midribs and veins of the leaves. The next two instars migrate to the larger twigs and branches and eventually moult into the adult 'female' (Morales, 1991). *Icerya purchasi* Maskell has 3 developmental stages with 3 instars of larvae.

Host Plants

The cottony cushion scale, *Icerya purchasi* Maskell, is extremely polyphagous and present data show that the insect is present on a large variety of host plants belonging to 85 families with 212 genera (scalenet.info). It can damage many types of fruit and forest trees, ornamental shrubs and trees, weeds. Important hosts include species of *Acacia*, *Casuarina*, *Citrus*, *Pittosporum* and *Punica*, causing significant economic damage on citrus and ornamentals (Tozlu et al., 2020; DaoXun et al., 2002; Kondo and Watson, 2022; bladmineerders.nl).

Plant Damage and Economic Importance

The pest cause many damage effects in plants as sap depletion, wilting, leaf drop, stunted growth, dieback and even plant death. Feeding by picking and sap sucking on plants, the insects excrete the hoenydew which cover the vegetal surfaces and leads to sooty mold growth, blocking light and air from leaves, disrupting photosynthesis, deforming the fruits and reduce the aesthetic value of the plants. The pest can destroy entire orchards. It can damage forest trees also (Kondo and Watson, 2022).

In the late nineteenth century, *Icerya purchasi* Maskell, the cottony cushion scale, was introduced in California (USA) and devastated the citrus orchards. In many other countries thaere was also recorded serious damage to citrus orchards, when the cottony cushion scale first arrived, but his biological control was successful (Kondo and Watson, 2022).

This scale was recorded in China (Anhui), as one of the most important pests of pomegranates (*Punica granatum* Linné) (DaoXun et al., 2002) and in Zhejiang is the main pest damaging Formosan-gum (*Liquidambar formosana* Hance) (Hua et al., 1999). In northern part of Israel, the cottony cushion scale was a serious pest

until biological control reduced the damage (Mendel and Blumberg, 1991). In Greece, *Icerya purchasi* Maskell prefers to attack rosemary stems initially and the leaves secondarily. Because of the many uses of rosemary, a reduction of its productivity would have a significant economic impact for Greece (Papadopoulou and Chryssohoides, 2012). In Turkey it has been regarded as an important citrus pest (*Citrus* spp. - Rutaceae), but also found on many medicinal and aromatic plants such as *Rosmarinus officinalis* Linné (Lamiaceae), *Foeniculumm vulgare* Miller (Apiaceae), *Nerium oleander* Linné (Apocynaceae), *Ricinus communis* Linné (Euphorbiaceae), *Ocimum basilicum* Linné (Lamiaceae), *Laurus nobilis* Linné (Lauraceae), *Alcea rosea* Linné (Malvaceae), *Passiflora quadrangularis* Linné (Passifloraceae), *Portulaca oleracea* Linné (Portulacaceae), *Rosa centifolia* Linné (Rosaceae), *Lantana camara* Linné (Verbenaceae), *Berberis* spp. (Berberidaceae), *Hibiscus* spp. (Malvaceae), *Salvia* spp. (Lamiaceae), *Senna* spp. (Fabaceae) (Kaydan et al., 2013, Elekcioğlu and Kaydan, 2021).

The uncontrolled infestation of cottony cushion scale has a severe effect on the pomiculture and horticulture industries and the endemic fauna of small islands (Tozlu et al., 2020).

Risk of Introduction

Icerya purchasi Maskell has a large distribution in the tropical and warmer temperate regions. Accidental introduction to new areas is possible through the movement of infested live plants through shipping or air transport/mail (CABI, 2021).

Means of Movement and Dispersal

The natural dispersal of cottony cushion scale is the first-instar crawler stage which often is spreaded by the wind passively. According to the pest monitoring data, the crawler young larvae were carried in the air at a height of 6 m over a distance of 3,5 km (Kondo and Watson, 2022). The crawlers may also be carried passively by animals and people that come into contact with the host plant. Prunings and harvesting infested plant material, e.g. fruit, aids dispersal by scattering the crawlers into the air, where the wind may carry them away. Other dispersal means are the infested clothes, agricultural working tools and vehicles of workers with larvae, having an important contribution to their spread (CABI, 2021).

Symptoms of Infection

Usually the pest can be observed along major veins on the lower surfaces of the leaves and on the stems of plants, in large groups with the white waxy ovisacs of females very noticeable. The presence of honeydew covered by sooty mould which attract the ants is also a typical symptom (Grafton-Cardwell, 2012).

Prevention and Control

Cultural Control

The localized infestations of *Icerya purchasi* Maskell can be selectively pruned from the plants and destroyed on the spot by burial or burning. To avoid the spread of the crawlers, care is necessary to manipulate without agitation the infested plant material (Kondo and Watson, 2022).

Biological Control

The regulation of *Icerya purchasi* Maskell by natural enemies is one of the classic success stories in biological control. When the cottony cushion scale was accidentally introduced in California (USA) in 1868-1869, it was fast growing as a major threat to the citrus production. In 1888, the United States Department of Agriculture (USDA), imported natural enemies from Australia, including the parasitoid fly species, *Cryptochaetum iceryae* Willinston and the vedalia beetle, *Novius (Rodolia) cardinalis* Mulsant to control the scale. Both species proved highly effective in controlling *Icerya purchasi* Maskell (Quezada and DeBach, 1973; Caltagirone and Doutt (1989; Kondo and Watson, 2022).

Various other natural enemies have been tried against I. purchasi, but with little success (CABI, 2021).

When there are used pesticides to control other pests in the same time with biological control, a careful management is recommended, because damage to the populations of biocontrol agent can cause an outbreak of *Icerya purchasi* Maskell, as recorded in South Africa by Hattingh and Tate (1995). The pest was inadvertent introduced into Taiwan and Japan and *Novius cardinalis* Mulsant was established as its natural enemy (Kuwana, 1922). In Israel during the 1980's severe outbreaks occurred in *Citrus* orchards and on ornamentals. A good control of the pest's population was obtained by importation of the coccinellid *Novius (Rodolia) iceryae* Jenson from South Africa and the parasitic fly *Cryptochaetum iceryae* Williston (Mendel and Blumberg, 1991). In Turkey good

results were achieved using some bioagents to control the pest: *Beauveria bassiana* Vuillemin, *Pseudomonas fluorescens* Migula and *Bacillus thuringiensis* subsp. *kenyae*. Carrying out field studies involving the bacteria strains and fungus isolate that are effective on the pest in the future is of great importance (Tozlu et al., 2020).

Chemical Control

Considering that both adults and larvae of cottony cushion scale, *Icerya purchasi* Maskell are covered with wax, this reduces the effectiveness of most chemical insecticides. In addition, the use of insecticides prevents regulation by natural enemies, which has proved to be highly successful. The chemical treaments should only be used for essential spot treatments. The best results are achieved against the first instar larvae (CABI, 2021; Kondo and Watson, 2022).

The insect may be controlled with growth regulators (pyriproxyfen, buprofezin), organophosphates (malathion), neonicotinoids (thiametoxam), syhnthetic pyrethroids, white oils, soap and horticultural oils (Mendel and Blumberg, 1991; Mendel et al., 1991; Jackson, 2021; Mohanny et al., 2022)

Materials and methods

The biological material was collected during April 2022, from rosemary plants (*Rosamarinus officinalis* Linné) in trading area of Cluj-Napoca. Two stages of cottony cushion scale were collected from infected plants: larvae and adults (females with ovisac). The insects were collected with the aid of fine brushes and tweezers, from different plant organs (stems, leaves, shoots). The collected biological material was directly introduced in small test tubes. Thereafter the material was brought in Laboratory of Entomology at University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca for identification and observations. Further, the stages of scale *Icerya purchasi* Maskell were determined and described. Observations of the specimens were done using a digital microscope LCD InfiniView CELESTRON and IOR ML-4M. Photographs of the specimens were done with the aid of a SONY digital photo-camera (13 Mpx) for macro photography.

Results and discussion

Our findings of the cottony cushion scale, *Icerya purchasi* Maskell on *Rosmarinus officinalis* Linné, follows similar findings recorded in Slovenia (Janežič F., 1954), Israel (Ben-Dov, 2011-2012), Greece (Papadopoulou and Chryssohoides, 2012), Slovakia (Kollár et al., 2016), Turkey (Elekcioğlu, 2018). The alien pest was found on rosmary plants in pots, as adult females and larvae.

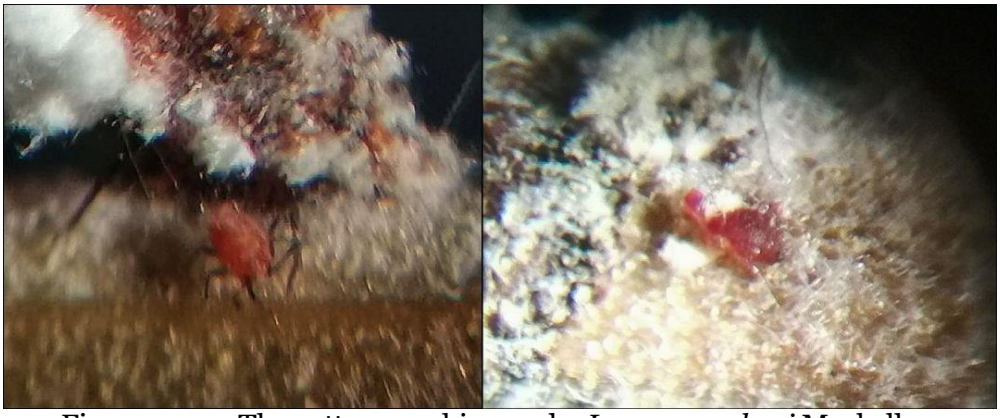
Following analysis of the collected material from infested rosemary plants, the adult female (hermaphrodite) of *Icerya purchasi* Maskell has an oval body of about 3-4 mm long, reddish-brown with a posterior ovisac attached on abdomen, white like cotton with ridges that make a longitudinal striation. The total body length of adult female with the ovisac is about 7-8 mm. The dorsal side is covered with white wax and there are many tufts in the marginal area and long projections of glassy thin filaments. The anntenae and legs are black (Figure 1-8; 11-12).

Figures 1-4. The cottony cushion scale, *Icery purchasi* Maskell – close-up view of adult female (hermarphrodite) with the waxy ovisac (Cluj-Napoca, 2022) (Photos by Horia Bunescu)

Figures 5-6. The cottony cushion scale, *Icery purchasi* Maskell – dorsal side of adult female (hermarphrodite) (Cluj-Napoca, 2022) (Photos by Horia Bunescu)

Figures 7-8. The cottony cushion scale, *Icery purchasi* Maskell –adult females (hermarphrodite) on host-plant stems (*Rosmarinus officinalis* Linné) (Cluj-Napoca, 2022) (Photos by Horia Bunescu)

The first instar larva is about 0,5-1 mm long with an elongated oval body, reddish. The thin anntenae and legs are black (Figure 9-10).



Figures 9-10. The cottony cushion scale, *Icerya purchasi* Maskell – first instar larva
(Cluj-Napoca, 2022) (Photos by Horia Bunescu)

Figures 11-12. The cottony cushion scale, *Icerya purchasi* Maskell on rosemary stems (*Rosamarinus officinalis* Linné): 11 – dorsal side of an adult female; 12 – adult females on dried rosmary stems
(Cluj-Napoca, 2022) (Photos by Horia Bunescu)

There are also reported the aspects concerning the damage of host-plants, *Rosamarinus officinalis* Linné. The infected rosmary plants with the cottony cushion scale, have discoloured, deformed and dry shoots. Following the feeding process, the insects eliminate honeydew spreading it on leaves, which promote the occurrence and development of sooty mold (*Capnodium* spp.), affecting the leaves. If there are not applied control measures, the plants dry out completely (Figures 11-12).

Conclusions

- The researches which carried out in trading area of Cluj-Napoca (Romania) in spring (April 2022), approaching problems in record of an important alien pest, the cottony cushion scale, *Icerya purchasi* Maskell, on rosemary, *Rosamarinus officinalis* Linné
- The scale is an invasive extremely polyphagous pest very easy spreading by trading plants
- The species has been identified according to the main external morphological characters as there are presented in literature
- There are collected from the infected rosemary stems adult females (hermaphrodites) and larvae being observed, measured, photographed with the corresponding description
- We consider that our report will be helpful to prevent the introduction, spread and control of this invasive pest, the cottony cushion scale, *Icerya purchasi* Maskell (Hemiptera: Monophlebidae)

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