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The scale insect *Coccus pseudomagnoliarum* (Kuwana) (Hemiptera: Coccomorpha: Coccidae) on citrus in Greece

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Summary Phenology and parasitism of the scale insect, *Coccus pseudomagnoliarum* (Kuwana) (Hemiptera: Coccomorpha: Coccidae), infesting *Citrus sinensis* (Rutaceae), were studied in Papagou area, in northeastern Athens, from June 2015 to June 2017. *Coccus pseudomagnoliarum* is a univoltine, viviparous, parthenogenetic species. It overwintered as settled 1st instar nymph on the shoots of the trees. The 2nd instar nymphs appeared between the beginning of April and the end of May, and the mature females were recorded from the beginning of May until the middle of June. The crawlers appeared between the middle of May and the middle of June and the 1st instar nymphs settled on the shoots at the end of May, where they remained during the whole summer period, winter, until the beginning of April next year. Parasitism of the scale was recorded between the beginning of May and the middle of May and reached a maximum rate of 35%. The recorded parasitoid species were *Coccophagus shillongensis* Hayat and Singh (Hymenoptera: Aphelinidae), *Coccophagus* spp. and *Metaphycus dispar* (Mercet) (Hymenoptera: Encyrtidae).

Additional keywords: *Coccus pseudomagnoliarum*, Coccidae, Greece, parasitism, phenology

Introduction

The citricola scale *Coccus pseudomagnoliarum*, has been recorded in Greece and in other regions of the world such as America (Arizona, California, Maryland), Australia, Azerbaijan, Croatia, Cyprus, France, Georgia, Iran, Israel, Italy, Japan, Korea, Russia, Sicily, Slovenia, South Spain, Syria, Turkey and Turkmenistan (García Morales *et al*., 2019).

Its host plants belong to the families: Apocynaceae (*Nerium oleander* L.), Berberidaceae (*Berberis* L.) Cannabaceae (*Celtis australis* L., *C. occidentalis* L., *C. sinensis* Pers.), Juglandaceae (*Juglans regia* L.), Lauraceae (*Laurus nobilis* L.), Lamiaceae (*Clerodendrum trichotomum* Thunberg), Lythraceae (*Punica granatum* L.), Myrtaceae [*Acca sellowiana* (Berg) Burret], Rhamnaceae (*Rhamnus pallasii* Fischer and Meyer), Rutaceae (*Citrus aurantium* L., *C. limon* (Linn.) Burm, *C. paradisi* Macfad, *C. reticulata* Blanco, *C. trifoliata* (L.), *Phellodendron amurense* Rupr.), Tamaricaceae (*Tamarix* L. sp.) and Ulmaceae (*Ulmus* L. sp., *Zelkova serrata* Thumb.) (García Morales *et al*., 2019).

Although *C. pseudomagnolarum* is not considered an important insect pest, in some countries serious damages are reported on citrus, recording high infestation densities of the scale. It has been referred as one of the most serious pest in the early 1990's on citrus in USA, Arizona and California [(Quayle, 1938; Kennett, 1988) in Trumble *et al*., 1995], but it was largely constrained in the 1940's due to applications of DDT and subsequent organochemical insecticides (Elmer *et al.* 1980). Its economic importance increased later again, because these insecticides lost their effectiveness due to resistance development (Trumble *et al*., 1995). Dreistadt (1996) studied the scale during 1991-1994 in USA, California and found that females and crawlers on Chinese hackberry *Celtis sinensis* (Cannabaceae) on untreated trees increased each year in comparison to previous years. The citricola scale was 5-25 times more abundant than the *Parthenolecanium* species combined: *Parthenolecani-*

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um corni (Bouché), *P. pruinosum* (Coquillett) and *P. cerasorum* (Cockerell) (Hemiptera: Coccidae).

The citricola scale completes one generation per year in several countries, as in USA (California) (Gill, 1988), Greece (Argyriou and Ioanides, 1975), Israel (Ben-Dov, 1980) and Australia (Smith *et al*., 1997). Gill (1988) reports that although males have been mentioned in bibliography, their actual existence is questionable and the scale reproduces parthenogenetically laying up to 2,000 eggs per female over a 1-2 month period. It is mentioned as an oviparous species overwintering at the stage of nymph (Gill, 1988; Argyriou and Ioannides, 1975).

The main natural enemies of *C. pseudomagnoliarum*, are many hymenopteran parasitoids species belonging to the families: Aphelinidae, Encyrtidae, Eulophidae and Pteromalidae (García Morales, *et al*., 2019; Mohamed *et al*., 2012).

In Greece, the citricola scale was recorded by De Lotto (1973) by the synonym *Coccus aegaeus* De Lotto, who found the scale on citrus in the island Rhodes in 1972. After its first record, Argyriou and Ioannides (1975) and Argyriou (1983) reported the presence of the scale in Greece, in Aegean islands Astypalaea and Chios on *Citrus* spp. Many years later, Japoshvili and Stathas (2017), recorded the citrocola scale in Athens on citrus, recording new parasitoid species for Europe infesting the scale. In the present study additional data are provided for the scale, concerning its biology, phenology and natural enemies in Greece. These data will contribute to enrich the existing information of citricola scale in Greece, since no further study on the scale was conducted in Greece during the last 40 years.

Materials and methods

The phenology and parasitism of *Coccus pseudomagnoliarum* were studied on infested *Citrus sinensis* (Rutaceae) in Papagou area, in northeastern Athens, from June 2015 to June 2017. Samples of fifteen infested shoots, 15 cm long, were taken every 15 days and were transferred in plastic bags to the laboratory, where examined under the stereoscope. The number of each developmental stage of the scale, the parasitized scales and the scales with encapsulated eggs of parasitoids were recorded. As parasitized were counted the scales containing parasitoids' larvae or nymphs and the scales with parasitoid exit holes. In each sampling, the number of each developmental stage of the scale, the parasitized scales and the scales containing encapsulated eggs of parasitoids were expressed as percentage (%) of the total number of scales.

The parasitized scales were kept in cylindrical plastic cages (diameter 3cm, hight 4cm, covered by organtin) under controlled conditions in incubators in the laboratory (temperature 25±1ºC, R.H. 65±2% and 16 hours light/day), until the emergence of the parasitoid adults.

The identification of the scale was made in the Laboratory of Entomology and Agricultural Zoology of the Technological Educational Institute of Peloponnese, using the key of Gill (1998). The species of the scale was confirmed by Professor Giuseppina Pellizzari (Dipartimento di Agronomia, Animali, Alimenti), University of Padua, Italy. The parasitoid species were identified by Professor George Japoshvili, (Institute of Entomology, Agricultural University of Georgia, Tbilisi).

Results

Coccus pseudomagnoliarum completed one generation per year. It is a parthenogenetic species, because no male larva, nymph or adult was recorded in the examined samples; it is viviparous because no egg or chorion of egg was found under the examined females during the present study. It overwintered as settled 1st instar nymph on the shoots of the trees (Fig. 1b). The 2nd instar nymphs appeared between the beginning of April and the end of May (Fig. 1c), and the mature females were recorded from the beginning of May until the middle of June (Fig.

1d, e). The crawlers appeared between the middle of May and the middle of June (Fig. 1a) and the 1st instar nymphs settled on the shoots at the end of May, where they remained during the whole summer period, winter, until the beginning of April next year. (Fig. 1b).

Parasitism of the scale was recorded to occur between the beginning of April and the middle of June in both years of the study, mainly on 2nd instar nymphs and less on pre-ovipositing females (Fig. 2). The highest parasitism rate reached 35% at the end of May 2017. The recorded parasitoid species were: *Coccophagus shillongensis* Hayat and Singh (Hymenoptera: Aphelinidae) (Fig. 3), and *Metaphycus dispar* (Mercet) (Hymenoptera: Encyrtidae). In addition, *Coccophagus* spp. were found. Scales with encapsulated eggs of parasitoids were found between the beginning of April and the end of May in both years and reached a maximum of 13% in the middle of May 2017 (Fig. 1f). Encapsulation was recorded mainly on the 2nd instar nymphs of the scale, which contained 1 to 6 encapsulated eggs (Fig. 4).

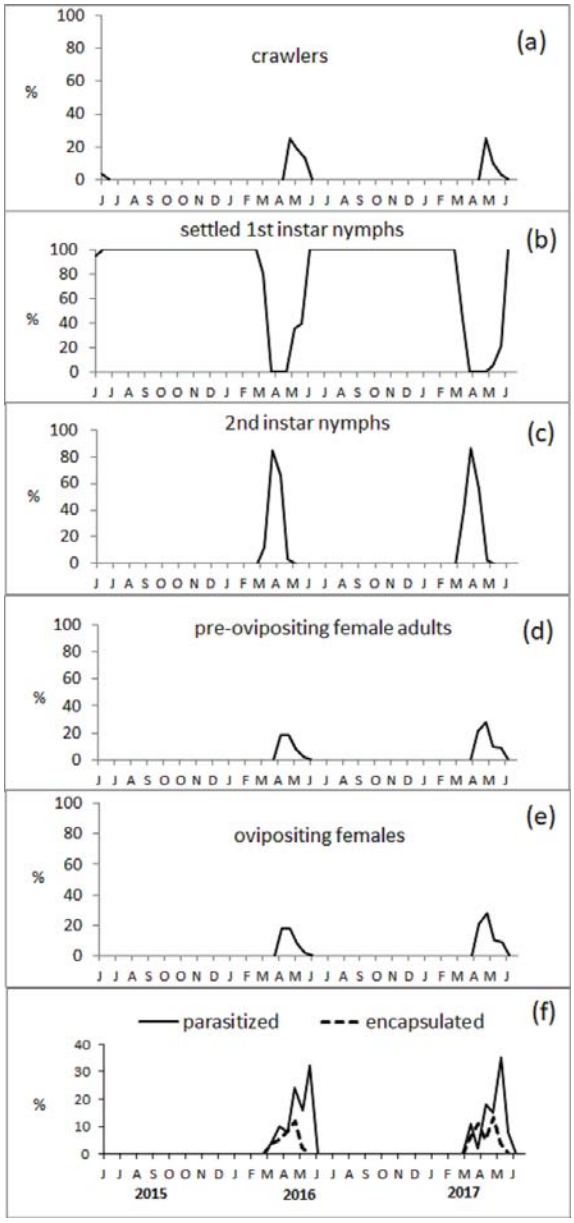

Figure 1. Percentage of developmental stages of *Coccus pseudomagnoliarum*, parasitism and encapsulation of the scale (associated parasitoid species *Coccophagus shillongensis*, *Coccophagus* spp., *Metaphycus dispar*) on *Citrus sinensis* in Papagou, Athens, from June 2015 to June 2017.

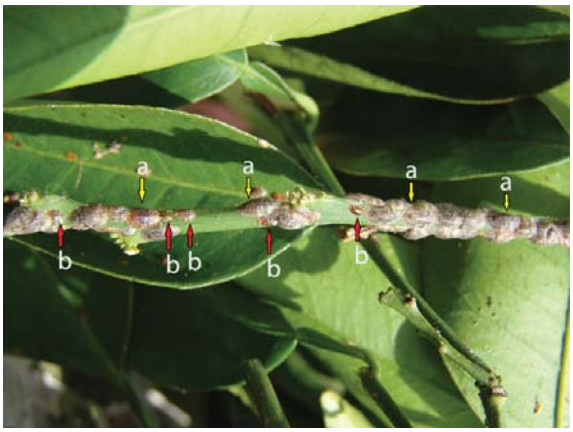

Figure 2. *Coccus pseudomagnoliarum* on *Citrus sinensis*: (a) preovipositing females; (b) parasitized scales.

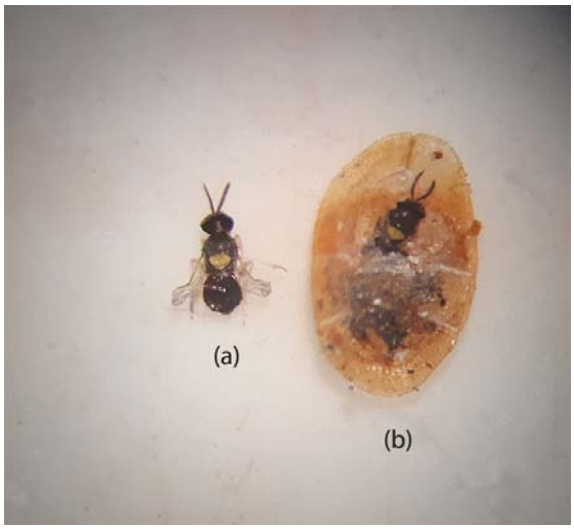

Figure 3. Parasitoid *Coccophagus shillongensis*: (a) adult; (b) in parasitized nymph of *Coccus pseudomagnoliarum*.

Figure 4. Encapsulated eggs of parasitoids (associated parasitoid species *Coccophagus shillongensis, Coccophagus* spp., *Metaphycus dispar*) by second instar nymphs of *Coccus pseudomagnoliarum*.

Discussion

The voltinism found for *C. pseudomagnoliarum* (one generation per year) in this study coincides with the findings for the scale in other studies, on the Greek island of Rhodes (Argyriou and Ioannides, 1975), in Israel (Ben-Dov, 1980) and in California (Gill, 1988).

According to the present study, females reproduce parthenogenetically as also reported by Ben-Dov (1993) and García Morales *et al*. (2019). Gill (1988) refers that males have been mentioned in the literature but their actual existence is questionable at the time. In the present study the scale appeared to be viviparous, because no eggs or chorion of eggs was found under the examined scales during both years of the study. Argyriou and Ioannidis (1975) reported oviposition by females and empty eggs after hatching of crawlers. Similarly, Gill (1988) stated that the crawlers hatch immediately from the eggs or over a period of several days.

Coccus pseudomagnoliarum was found parasitized by *C. shillongensis, M. dispar* and *Coccophagus* unidentified species at the location near Athens. This record of *C. shillongensis* has actually been the first one in Europe (Japoshvili and Stathas, 2017). Argyriou and Ioannides (1975) have reported *Coccophagus licimnia* Walker (Hymenoptera: Aphelinidae) and *Metaphycus* sp. near *insidiosus* Mercet (Hymenoptera: Encyrtidae) with a maximum parasitism rate of 25% on the Greek island of Rhodes as well as the predators *Chilocorus bipustulatus* L. and *Exochomus quadripustulatus* L. (Coleoptera: Coccinellidae).

Encapsulation of parasitoid eggs by *C. pseudomagnoliarum* is related to the species *C. shillongensis, M. dispar* and *Coccophagus* spp. Tena and Garcia-Mari (2008) report high encapsulation levels of *Metaphycus helvolus* (Compere) (Hymenoptera: Encytridae) by the citricola scale on citrus in Spain, once the scale length reaches 2 mm at the end of spring, which reduce the efficiency of the parasitoid. A further study on the ecology of the recorded parasitoid species is considered important in order to clarify the contribution of each parasitoid species to the total parasitism of the scale, the relationship among the parasitoid's population and the influence of encapsulation on each species.

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Literature cited

Argyriou, L.C. and Ioannides, A.G. 1975. *Coccus aegaeus* (Homoptera, Coccoidea, Coccidae) De Lotto: nouvelle espèce de lecanine des Citrus en Grèce. [*Coccus aegaeus* (Homoptera, Coccoidea, Coccidae): a new species of soft scale from citrus in Greece.]. *Fruits,* 30: 161-162.

Argyriou, L.C. 1983. Faunal analysis of some scale insects in Greece. *Proceedings of the 10th International Symposium of Central European Entomofaunistics*, Budapest, 15-20 August 1983 364-367.

Ben-Dov, Y. 1980. Observations on scale insects (Homoptera: Coccoidea) of the Middle East. *Bulletin of Entomological Research,* 70: 261-271.

Ben-Dov, Y. 1993. *A systematic catalogue of the soft scale insects of the world.* Sandhill Crane Press Gainesville, FL 536 pp.

De Lotto, G. 1973. A new soft scale from citrus (Homoptera: Coccoidea: Coccidae). Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri'. *Portici,* 30: 291-293.

Dreistadt, S.H. 1996. Citricola scale (Homoptera: Coccidae) abundance on Chinese hackberry and scale control with spray oil or acephate

trunk implants. *Journal of Economic Entomology,* 89: 481-487.

Elmer, H.S., Brawner, O.L. and Ewart, W.H. 1980. California red scale predator may create citricola control dilemma. *California Agriculture,* 34: 20-21.

García Morales M., Denno B.D., Miller, D.R., Miller, G.L., Ben-Dov, Y. & Hardy, N.B. 2016. ScaleNet: A literature-based model of scale insect biology and systematics. Database. doi: 10.1093/database/bav118. http://scalenet.info. (Accessed: 5/11/2019).

Gill, R.J. 1988. The scale insects of California. Part 1. The Soft Scales (Homoptera: Coccoidea: Coccidae). State of California, Department of Food and Agriculture Division of Plant Industry, 132 p.

Japoshvili, G.O. & Stathas, G.J. 2017. New record of *Coccophagus shillongensis* Hayat and Singh (Hymenoptera: Aphelinidae) from Europe, with some remarks on morphological variation. *Phytoparasitica,* 45: 651–653.

Mohamed, E.M., Basheer, A.M. & Abukaf, N. 2012. Survey of parasitoid species of citricola scale insect, *Coccus pseudomagnoliarum* (Kuwana) (Homoptera: Coccidae) and their effect in citrus orchards at Lattakia, Syria. *Egyptian Journal of Biological Pest Control,* 22: 61-65.

Smith, D., Beattie, G.A.C. and Broadley, R.H. 1997. *Citrus Pests and their Natural Enemies: Integrated Pest Management in Australia. State of Queensland*, Dept. of Primary Industries, and Horticultural Research and Development Corp. Brisbane, Australia 263 pp.

Tena, A. & Garcia-Mari, F. 2008. 2008. Suitability of citricola scale *Coccus pseudomagnoliarum* (Hemiptera: Coccidae) as host of *Metaphycus helvolus* (Hymenoptera: Encyrtidae): Influence of host size and encapsulation. *Biological Control,* 46 (3): 341-347.

Trumble, J.T., Grafton-Cardwell, E.E., & Brewer, M.J. 1995. Spatial dispersion and binomial sequential sampling for citricola scale (Homoptera: Coccidae) on citrus. *Journal of Economic Entomology,* 88: 897-902.

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Το κοκκοειδές έντομο *Coccus pseudomagnoliarum* (Kuwana) (Hemiptera, Coccomorpha, Coccidae) σε εσπεριδοειδή στην Ελλάδα

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Περίληψη Μελετήθηκε η φαινολογία και ο παρασιτισμός του κοκκοειδούς εντόμου *Coccus pseudomagnoliarum* (Kuwana) (Hemiptera: Coccomorpha: Coccidae), σε προσβολές εσπεριδοειδών *Citrus sinensis* (Rutaceae), κατά την περίοδο Ιουνίου 2015 - Ιουνίου 2017, στο βορειοανατολικό προάστιο Παπάγου της Αθήνας. Το *C. pseudomagnoliarum* συμπληρώνει μία γενεά το έτος, είναι είδος ζωοτόκο και παρθενογενετικό. Διαχείμασε ως σταθεροποιηθείσα νύμφη 1ης ηλικίας επί των προσβεβλημένων βλαστών. Οι νύμφες 2ης ηλικίας παρατηρήθηκαν από τις αρχές Απριλίου έως τα τέλη Μαΐου και τα ώριμα θήλεα από τις αρχές Μαΐου μέχρι τα μέσα Ιουνίου. Έρπουσες παρατηρήθηκαν από τα μέσα Μαΐου έως μέχρι τα μέσα Ιουνίου και οι σταθεροποιηθείσες νύμφες 1ης ηλικίας περί τα μέσα Μαΐου, όπου παρέμειναν στο στάδιο αυτό επί των βλαστών καθ' όλη τη θερινή και χειμερινή περίοδο, μέχρι τις αρχές Απριλίου του επόμενου έτους. Παρασιτισμός του κοκκοειδούς παρατηρήθηκε από τις αρχές έως τα μέσα Μαΐου και ανήλθε σε ποσοστό 35%. Τα είδη των παρασιτοειδών που βρέθηκαν ήταν τα *Coccophagus shillongensis* Hayat and Singh (Hymenoptera: Aphelinidae), *Coccophagus* spp. και *Metaphycus dispar* (Mercet) (Hymenoptera: Encyrtidae).

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