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# Survey of Natural Enemies of Fig Wax Scale *Ceroplastes rusci* L. (Homoptera: Coccidae) and Seasonal Abundance of the Parasitoid *Scutellista caerulea* Fonscolombe (Hymenoptera: Pteromalidae) in Jordan

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## ABSTRACT

The parasitic and predatory complex of fig wax scale (FWS), *Ceroplastes rusci* L. (Homoptera: Coccidae), was surveyed in Jordan during two years (2006-2007). 100 FWS infested samples from five plant species (fig, wild fig, oleander, poplar and mistletoe) from 43 different locations were sampled. Five parasitoids belonging to four families of Hymenoptera were reared from the FWS. *Scutellista caerulea* Fonscolombe (Hymenoptera: Pteromalidae) was the most abundant parasitoid. It was collected form 91% of the surveyed locations. The predators belong to Coleoptera, Lepidoptera, Neuroptera, Thysanoptera and Acari. The seasonal trend of *Scutellista caerulea* was also studied at two sites.

**Keywords**: *Ceroplastes rusci*, *Scutellista caerulea*, Natural enemies, Fig, Jordan.

## INTRODUCTION

The area planted with common fig *Ficus carica* L. is estimated to 540 ha representing 0.8% of the total area cultivated with fruit trees (Department of Statistics, 2006). Furthermore, there are uncountable numbers of fig trees scattered in the home gardens or in the borders of olives, stone fruits and grape orchards. The total annual production of fresh fig is about 3400 MT.

Fig wax scale (FWS), *Ceroplastes rusci* L., is one of the common scale insect species in Jordan. It has been reported as a serious pest of fig (Khasawineh and Talhouk, 1964; Talhouk, 1969; Mustafa-Al-Antary and Sharaf, 1994). This insect attacks almost all parts of the trees including leaves, twigs and fruits. Heavily infested plants appear unhealthy and the scales encrust the twigs and petioles. It damages the trees by sucking plant sap and covering vegetation with excreted honeydew. The honeydew assembles on the lower leaves, fruits and branches (Abu-Huiege, 1962; Al-Momany and Al-Antary, 2008). Sooty mold fungus grows on it and dust accumulates on the sticky substances. The leaves, twigs and fruits become black stained. The fungal layer interferes with the penetration of sunlight and reduces photosynthesis, transpiration and subsequently crop quality and quantity.

Numerous predators and parasitoids had been reported attacking FWS (Table 1). Bénassy and Biliotti (1963) considered the natural enemies of FWS as the most important factor controlling the occurrence and severity of infection. In Jordan, a few information is available on natural enemies of this insect. Talhouk (1969) recorded the presence of three natural enemies from Jordan. These are: *Scutellista caerulea* Fonscolombe, *Tetrastichus* sp. and *Coccidophaga scitula* Ramb.

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**Table 1. Predators and parasitoids associated with fig wax scale in the world.**

| Family | Species | References |
|---|---|---|
| Encyrtidae | *Paraceraptocerus italicus* (Masi) | Argyriou and Santorini (1980) |
| | *Microtyres falvus* (How.) | Hammad (2006) |
| | *Bothriophryne* sp. | Hammad (2006) |
| Aphelinidae | *Coccophagous lyciminia* (Walker) | Bénassay and Biliotti (1963) |
| | | Argyriou and Santorini (1980) |
| | | Özsemerci and Aksit (2003) |
| Eulophidae | *Tetrastichus ceroplastae* (Girault) [*Aprostocetus ceroplastae* (Girault)] | Talhouk (1969) |
| | | Bénassy and Franco (1974) |
| | | Argyriou and Santorini (1980) |
| | | Özsemerci and Aksit (2003) |
| | | Morsi and Mousa (2004) |
| | | Hammad (2006) |
| | *T. gibbus* | Bénassay and Biliotti (1963) |
| | *Tetrastichus ceroplastophilus* (Domenichini) | Bénassay and Biliotti (1963) |
| | | Bénassy and Franco (1974) |
| | | Argyriou and Santorini (1980) |
| | | Özsemerci and Aksit (2003) |
| | *Marietta exitiosa* (Compare) *M.* sp. | Morsi and Mousa (2004) |
| | *M. exitiosa* (Compare) | Hammad (2006) |
| | *Metaphycus dispar* (Mercet) | Özsemerci and Aksit (2003) |
| | *M. helvolus* (Compare) | Morsi and Mousa (2004) |
| | *M. zebratus* (Mercit) | Morsi and Mousa (2004) |
| | | Hammad (2006) |
| | *Pachyneuron concolor* Forster [*P. muscarum* L.] | Özsemerci and Aksit (2003) |

| | | |
|---|---|---|
| Pteromalidae | *Scutellista cyanea* (Motsch) [=*Scutellista caerulea* Fonscolombe] | Abu-Huiege (1962)<br>Khasawineh and Talhouk (1964)<br>Bénassay and Biliotti (1963)<br>Talhouk (1969)<br>Inserra (1971)<br>Argyriou and Santorini (1980)<br>Al-Rouechdi *et al*. (1996)<br>Morsi and Mousa (2004) |
| | *Tomocera californica* (How.) | Hammad (2006)<br>Bénassay and Biliotti (1963) |
| Coccinellidae | *Chillocorus bipustulatus* (L.) | Abu-Huiege (1962)<br>Khasawineh and Talhouk (1964)<br>Inserra (1971)<br>Özsemerci and Aksit (2003)<br>Hammad (2006) |
| | *Pharocymnus ovoidues* (Sicard)<br>*Cydonia vicina isis* (Cr.) | Hammad (2006) |
| | *Exochomus quadripustulatus (L.)* | Inserra (1971)<br>Rouechdi *et al*. (1996) |
| | *Scymnus subvillosus* (Goeze)<br>*Scymnus rubromaculatus*(Goeze)<br>*Synharmonia conglobata* [*Oenopia conglobata* L.] | Özsemerci and Aksit (2003) |
| Noctuidae | *Eublemma scitula* Ramb.<br>[*Coccidiphaga scitula* Ramb.] | Argyriou<br>and Santorini (1962)<br>Khasawineh and Talhouk (1964)<br>Inserra (1971)<br>Özsemerci and Aksit (2003)<br>Hammad (2006) |
| | *Eublemma amabilis* (Moore) | Vu *et al*. (2006) |

| | | |
|---|---|---|
| Anthocoridae | | Al-Rouechdi *et al*. (1996)<br>Amin (2000) |
| Neuroptera | *Chrysoperla carnea (Stephens)*<br>*Anisochrya prasina*<br>*A. flavi frons* | Al-Rouechdi *et al*. (1996) |
| Phloeothripdae | | Amin (2000) |
| Phytoseiidae | | Amin (2000) |
| Pleosporaceae | *Alternaria infectoria* (Simmons) (pathogenic agent) | Shabana and Ragab (1997) |

Previous studies of the parasitoid complex associated with FWS around the world have identified four dominant parasitoid species. These include *Scutellista caerulea* (Fonscolombe) (= S.*cyanea* Motsch.), *Metaphycus* spp., *Coccophagous lyciminia* (Walker) and *Tetrastichus* spp.

*S. caerulea* is a widely distributed egg-feeder of many coccid insects (Prokopenko and Mokrousova 1981; Shaaban *et al.*, 2003). It was reported as an imported parasitoid of the olive black scale *Saissetia oleae* (Orphanides, 1988). Many previous reports considered *S. caerulea* as an unusual natural enemy because it develops either as a parasitoid or a predator (Ehler, 1989). When host eggs are unavailable, the larva is able to develop as an external parasitoid. Much work had been carried out on *S. caerulea* in olive groves (Orphanides, 1988; Shaaban *et al.* 2003; Kumral and Kovanci, 2004), whereas little attention had been paid to this parasitoid on FWS (Ragab, 1995). Earlier work provided significant information on the biology, seasonal abundance and description of this species (Bodenhiemer, 1951; Saad *et al.*, 1977; Ehler, 1978; Prokopenko and Mokrousova, 1981 and 1983; Ibrahim, 1984). Khasawineh and Talhouk (1964) considered *S. caerulea* among the most active parasitoids. The highest monthly percentage of parasitism on FWS was reported to be 35-40% in Syria (Al-Hariri, 1980) in September and November, whereas a higher level of parasitism (65%) was reported in Italy (Inserra, 1971).

*Metaphycus* spp., an important FWS parasitoid, was reported by several workers (Özsemerci and Aksit, 2003; Morsi and Mousa, 2004; Hammad, 2006), but its efficacy on FWS is unknown.

The aim of this work is to report the natural enemies of fig wax scale (FWS) *C. rusci* and the seasonal abundance of one of its parasitoids in Jordan.

## MATERIALS AND METHODS

### Parasitoids and Predators Associations

100 trees from 43 different locations were sampled in Jordan. Ten leaves infested with *C. rusci* were collected randomly from different fig orchards during spring, summer and autumn months of 2006 and 2007. Each location was sampled once and the samples were taken for laboratory inspection. Abandoned orchards were preferably checked. The leaves were kept in a well-ventilated glass jar and monitored weekly for adult parasitoids emergence. FWS infested plant parts were examined visually for

predators in the field. Adult predators were collected by an aspirator when they were observed feeding on scale insects. Larvae of predators which were found during working in the laboratory were kept in a Petri dish until emergence (in case they pupated early).

The emerging parasitoids were transferred into glass vials containing 70% ethanol and identified to the generic level by using the key of Rosen (1967) and Universal Chalcidoidea Database with the assistance of Dr. Abid Al-Naby Basher from Damascus University. In case of uncertainty, specimens were left and described in the results survey table as unidentified. The predators were identified by the researchers using the collection of Jordan University Museum. The percentages of surveyed locations where each species was collected were then calculated.

Also, some scales were examined under the stereomicroscope for accurate inspection. Predatory mites and thrips were collected from the caged samples and kept in 60% ethanol. Yellow sticky traps (20X30cm) were also used in May and June in 2006 and 2007 to monitor the first flight activity of FWS parasitoids in Al-Salt and Wadi-Shuieb fig sites. Cards of the traps were collected and transferred to laboratory for microscopic examination. These cards were replaced every three weeks.

**Seasonal Abundance of *Scutellista caerulea***

Ten fig trees from Al-Salt fig site and five trees from Wadi-Shuieb fig site were chosen for sampling. Ten fig leaves were collected randomly from each tree once each month, from January to December during the two years, 2006 and 2007. In the laboratory, different numbers of scales were randomly chosen and examined under the microscope for the presence of larvae or pupae of *S. caerulea*. The monthly percentage of parasitism by *S. caerulea* in the two sites was calculated by dividing the total number of parasitized scale by larvae and pupae over the total number of inspected scales, multiplied by 100.

Sex ratio was defined in June, July and August in Al-Salt fig orchard. The collected pupae were counted and kept in a well ventilated glass jar and monitored weekly for adult parasitoids emerging. The emerged individuals were counted under the microscope to determine the female: male ratio.

## RESULTS

**Parasitoids and Predators Associations**

The parasitic and predatory insects associated with five FWS infested plant species (fig, wild fig, oleander, poplar and mistletoe) in the surveyed areas in Jordan are listed in Table (2). Five parasitoids belonging to four families of Hymenoptera were reared from FWS. The predators belong to Coleoptera, Lepidoptera, Neuroptera, Thysanoptera and Acari.

**Table 2. Parasitoids and predators associated with fig wax scale infesting five plant species in Jordan during 2006-2007.**

| Family | Species |
|---|---|
| Pteromalidae | *Scutellista caerulea* Fonscolombe |
| Encyrtidae | *Anicetus* sp. |
| | *Metaphycus* sp. |
| Eulophidae | *Tetrastichus* sp. |
| | *Coccophagous* sp. |

| | |
|---|---|
| Noctuidae | *Eublemma scitula* (Ramb.) |
| Coccinellidae | *Coccinella septempuntata* L.<br>*Chillocorus bipustulatus*<br>*Scymnus* sp.<br>*Oenopia* sp.<br>*Nephus bepistulatus* |
| Chrysopidae | *Chrysoperla carnea* Stephens<br>*Chrysopa pirla* |
| Thripidae | Unidentified |
| Predaceous mite | Unidentified |
| Pyemotidae | *Pyemotes* sp. (hyperparasitoid) |
| Pleosporaceae | *Alternaria* sp.(pathogenic agent) |

*S. caerulea* was the most abundant parasitoid. It was collected form 91% of the surveyed locations (Figure1) from infested five plant species (fig, wild fig, oleander, poplar and mistletoe). Results of FWS dissection in the laboratory indicated that *S. caerulea* parasitized all the stages except the first stage, possibly because the individuals of this stage were very small to be parasitized. *S. caerulea* overwintered as young larvae under the overwintering scales or pupae in the old scales. Mostly, the individuals who overwintered as adults or pupae perished inside the scales in the winter. Male: female ratio was found to be approximately 1:1 in the studied months. Scale sizes were greatly influenced by the parasitoid sizes. Large parasitoid females emerged from large scales. The sizes of *S. caerulea* pupae were greatly variable. Also, large pest females were more preferable to be attacked with *S. caerulea*.

*Metaphycus* sp. was the second most common parasitoid. It was collected from 30 % of the surveyed locations (Figure 1). The parasitoid develops inside the late second and early third stage nymphs and kills them. It overwinters as pupae within the body of the scale. The parasitized scales appeared yellow and flat, and the wax layer was thin. Also, the ventral side of the scale was very thin and transparent. The parasitoid larvae pupated inside the scale body emerged by cutting a circular hole in the dead scale. Many larvae developed inside the same scale. They were found in small numbers with the exception of Moqablin site in Amman Governorate where their activity was more noticeable. They were more abundant in November samples.

*Anicetus* sp. was collected from 23% of the surveyed locations (Figure 1). Adults were reared from third stage nymphs and adults. High activity of this species was observed during September and October.

*Tetrastichus* sp. was recovered from FWS collected

from ten sites in October and November in 2006-2007. Parasitization by this species was low at all locations. *Coccophagous* sp. was recorded at low population from 26% of the locations (Figure 1). It was reared from third nymphal stage and young adult females.

*E. scitula* was collected from three locations, but was most abundant at Mrajmeh site in Madaba. The larvae cover the body with a light silken web to which numerous host remains were attached. This serves as a shield to protect them from ants. *E. scitula* overwintered as pupae under the shield-like case on the lower twigs. In the laboratory, adults emerged from collected pupae in July and laid eggs on the tissue which cover the jar. The eggs were orange, round and flattened on the top.

Five coleopterans, namely; *Chilocorus bipustulatus* L., two *Scymnus* spp. and *Oenopia* sp. and *Coccinella septempuntata* were observed to feed heavily on FWS in different locations and in the laboratory. The lady bird beetle adults *(C. septempuntata)* were commonly encountered in September in 2006-2007.

Two chrysopids were also collected. Larvae of the green lace wings *Chrysoperla carnea* Seph. were heavily observed on FWS in abandoned orchards. The other chrysopid species *Chrysopa pirla* was recorded in Al-Salt at one location. Feeding on FWS was observed also in the laboratory. Unidentified species of Thripidae was collected from one location.

Different species of mite were found inside or under the scales. Phytoseiid mite was noticeably abundant at the beginning of spring. The hyperparasitoid *Pyemotes* sp. was found attacking larvae, pupae and adults of *S. caerulea* inside the insect scale. The percentage of parasitism reached 80% in some orchards in Wadi-Shuieb. This pyemotoid mite was reported for the first time on *S. caerulea* in Jordan.

Other insects, including various members of Hymenoptera, were noticed in different orchards, which might have been collecting honeydew from the FWS. Also, scale crawlers were seen trapped in webs of spiders.

One entomopathogenic fungus *Alternaria* sp. was identified by using the description of http:// ag.arizona.edu/plp/alternaria/online website. The spores were isolated from healthy young scales at one site (Al-Salt). However, *Alternaria* species are known as major plant pathogens. *A. alternata* has been recorded causing leaf spot and other diseases to over 380 host plant species http://en.wikipedia. org/eiki/ Alternaria_ alternata. It is an opportunistic pathogen on numerous hosts causing leaf spots, rots and blights to many plant parts (Serdani *et al*., 1998). It also causes upper respiratory tract infections in AIDs patients and asthma in people with sensitivity http://en.wikipedia. org/ eiki/ Alternaria_alternata. *A. alternata* was also isolated from dying or dead aphids. The fungus infested the first and second instars. The immature conidia were noticed in the body sap of scales during dissecting. The mature conidia were clearly apparent on a slide preparation when the scale was lifted on the bench for one week to dry up.

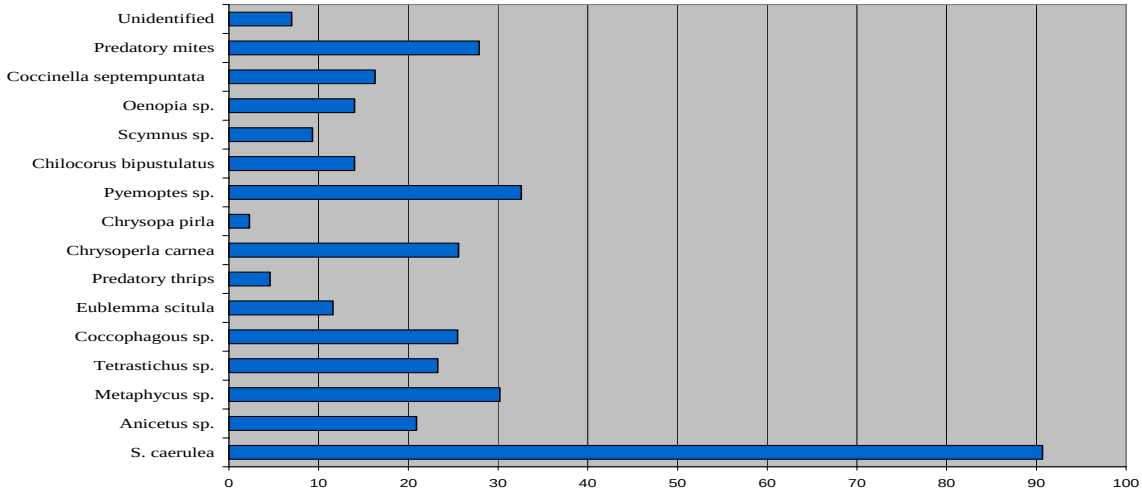


**Figure 1. The percentage of surveyed locations where each species was collected.**

**Seasonal Abundance of *S. caerulea***

Adults of *S. caerulea* were observed and captured on sticky cards early in late May in Wadi-Shuieb and delayed to mid-June in Al-Salt in both years (2006 and 2007) (Figure 2). Data from both sites showed that *Scutellista* larvae and pupae were present throughout both years. Based on the number of larvae and pupae in the inspected samples at both sites, higher rates of parasitism were exhibited in Wadi-Shuieb compared to Al-Salt (Figure 2). In Al-Salt, a gradual accumulation of parasitoids was noticed after June reaching a peak of 53% and 63% in 2006 and 2007, respectively. In Wadi-Shuieb, peaks of abundance were achieved in October (75%) in 2006 and in September (70%) in 2007. The percentages of parasitism in both sites decreased sharply in November and December in both years.

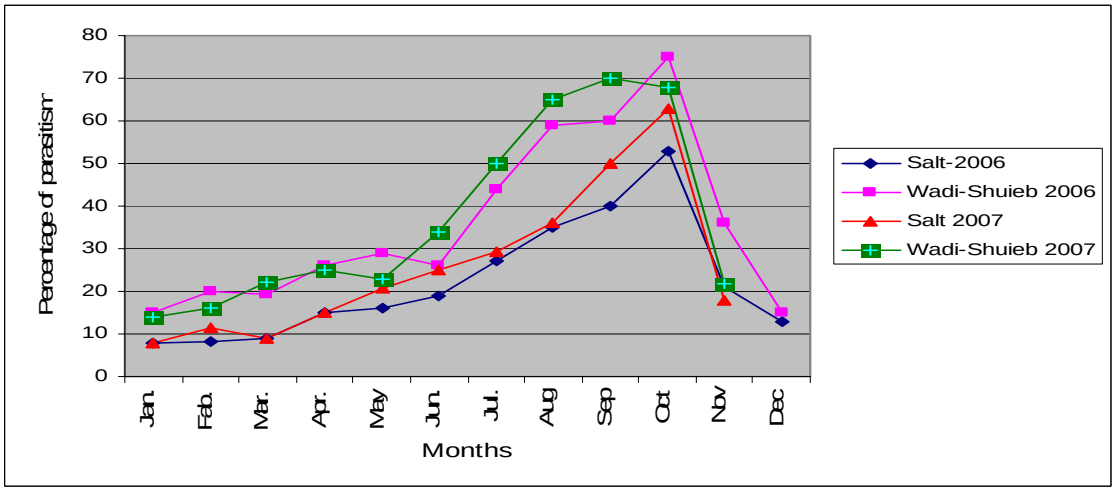


**Figure 2. Seasonal abundance of *S. caerulea* (larvae+pupae) in Al-Salt and Wadi-Shuieb in 2006 and 2007.**

## DISCUSSION

A complex of entomophagous insects parasitizing FWS was found in the surveyed areas in Jordan. Except for *S. caerulea*, *Tetrastichus* and *Coccidiphaga scitula* (Talhouk, 1969), all others on the list are recorded for the first time on FWS in Jordan.

*S. caerulea* was known as a common predator on coccids in various regions (El-Minshawy *et al.,* 1978; Kumral and Kovanci, 2004). Most of literature considered *S. caerulea* an ineffective predator, since it consumes only up to 75% of the host eggs and a considerable percentage of host offspring of the attacked scales remains able to complete development unharmed (Rosen, 1967; McCoy and Selhime, 1971; Argyriou and Santorini, 1980). Many crawlers couldn't get out because of the presence of *S. caerulea* pupae. More than 500 hatched dead crawlers were counted inside the parasitized scales.

Results of seasonal abundance of *S. caerulea* showed that there were clear variations during the two years at the two sites. Availability of the parasitizable stages of FWS and effect of extreme temperature might explain this fluctuation. Higher percentage of parasitism by larvae and pupae occurred in September and October in 2006 and 2007 in Wadi-Shuieb with a delay until November in Al-Salt in both years. This coincided with the availability of third and mature host stages. The results on seasonal abundance of *S. caerulea* are consistent with the findings of other studies (Ragab, 1995). FWS start hatching and developing in Wadi-Shuieb 2-4 weeks earlier than in Al-Salt. In spite of the fact of *S. caerulea* being attacked by the pyemotid mite in both sites, percentage of parasitism was found to be higher in Wadi-Shuieb compared to Al-Salt. This might be attributed to higher temperatures in the former site. The strong influence of temperature on phenology of *S. caerulea* was shown by Ibrahim (1984), who found that increasing temperature within limits increased the total number of eggs deposited by S. *caerulea*. On the other hand, *S. caerulea* might enter a diapause when the environmental conditions were unfavorable or when its host entered a diapause (Bodenhiemer, 1951). In December, the decrease in temperature and leaves shedding affected both the host and the predator. The result of sex ratio coincided with the result reported by Saad *et al.* (1977) who reported 1:1 male to female ratio most the time.

*Metaphycus* sp., an important parasitoid on the black scale *S. oleae* (Tena *et al.,* 2008), showed good percentage of occurrence (30%) which indicted that this is an important parasitoid of the highlighted scale.

In this study, *Anicetus* was reported for the first time in Jordan. It was reported in Egypt as a parasitoid of *Ceroplastes africanus* (Hamed and Hassanein, 1990). *C. rusci* is a new host record of this species.

Natural enemies are considered to be an important factor in maintaining FWS population at low level (Argyriou and Santorini, 1980), but apparently not adequate in reducing the host numbers effectively during the season in the surveyed areas. In spite of the fact that the percentage of parasitism by *S. caerulea* was much higher than those reported in earlier literature (Inserra, 1971; Al-Hariri, 1980; Ragab, 1995), its action didn't seem to have a significant effect upon the population of FWS. This might be due to a number of factors. Laboratory dissection of different stages of FWS revealed *S. caerulea* strongly being attacked by the pyemotid mite *Pyemotes* sp. This finding is of paramount importance to the biological control of FWS or even the black scale *S. oleae*, and the reason might be the fact of *S. caerulea* having a limited influence on FWS in all infested areas. However, the parasitoid that was parasitized by the *Pyemotes* sp. Produced offspring.

Furthermore, applying insecticides for controlling FWS was commonly used in June after crawler

emergence. Most of the sprayed insecticides stayed active for 2-3 weeks after spraying coinciding with the emergence of *S. caerulea* adults. Fortunately, *S. caerulea* adults avoided the pesticide partially by gradual emerging. Data on natural enemies suggest the assistance of a pest management specialist in developing IBM programs. For example, transfer and establishment of natural enemies such as the parasitic wasp *Anicetus* sp. and the noctoid moth *E. scitula* found abundant at two locations to other parts of Jordan are therefore more likely to improve the biological control.

The entomophagous fungus *Alternaria infectoria* was reported as a good bio agent of FWS by Shabana and Ragab (1997). In the present study, the low incidence of *Alternaria* sp. at the time of survey might be due to dry weather conditions.

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# الطفيليات والمفترسات التي تهاجم حشرة التين الشمعية *Ceroplastes rusci* L.، والانتشار الموسمي للمتطفّل *S.caerulea* في الأردن

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## ملخـص

تم حصر الطفيليات والمفترسات التي تهاجم حشرة التين الشمعية *Ceroplastes rusci* L. في الأردن خلال العامين 2006-2007 . تم جمع 100 عينة من خمسة أنواع نباتية مصابة بقشرية التين الشمعية (التين والتين البري والدفلة والحور والدبق) من 43 موقعاً. وجدت خمسة متطفلات تابعة لأربع فصائل من رتبة غشائية الأجنحة Hymenoptera. المتطفل *Scutellista caerulea* كان الأكثر شيوعاً وقد جمع من 91 % من المواقع الممسوحة . وتتبع المفترسات رتبة غمدية الأجنحة (Coleoptera) ورتبة حرشفية الأجنحة (Lepidoptera) ورتبة شبكية الأجنحة (Neuroptera) ورتبة هدبية الأجنحة (Thysanoptera) والاكاروسات (Acari). كما تمت دراسة الانتشار الموسمي للمتطفل *S.caerulea* ونسبة التطفل في موقعين.

**الكلمات الدالة**: *Ceroplastes rusci* ، *Scutellista caerulea* ، الأعداء الطبيعية، التين، الأردن.

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