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Parasitoids belonging to the genus *Aphytis* Howard (Hymenoptera: Aphelinidae) in Citrus orchards in Lattakia, Syria

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A survey of the common *Aphytis* spp. Howard (Hymenoptera: Aphelinidae) parasitoids was carried out at four citrus orchards (which were not treated with chemical pesticides) in AL-Hanade, Stamo, Tarjano and Hmaiem in Lattakia Governorate from September 2010 to September 2011. Six parasitoid species of the genus *Aphytis* were reared from living armoured scale insects isolated in four states. They were *Aphytis lepidosaphes* (Compere), *Aphytis lingnanesis* (Compere), *Aphytis chrysomphali* (Mercet), *Aphytis melinus* (DeBach), *Aphytis maculicornis* (Masi) and *Aphytis hispanicus* (Mercet).

Introduction

Citrus is an important crop in Syria in terms of both the amount of production and the variety. Ninety-two percent of the citrus are grown in the Mediterranean Region. California red scale, *Aonidiella aurantii* (Maskell), Purple scale *Lepidosaphes beckii* (Newman) and Chaff scale *Parlatoria pergandii* (Comstock) (Homoptera: Diaspididae) are important pests of Citrus trees and can cause various types of damage (Basheer, 1990; Mohammad, 2008). With their piercing, tubular mouthparts scale insects consume plant sap and can thereby weaken plants if their populations exceed a certain density. Plants weakened by scale infestations are generally more susceptible to attack by other insects and fungal diseases. Moreover, certain scale insects (mealybugs and soft scales) excrete honeydew which supports growth of unsightly sooty moulds. Scale insects are difficult to control, even with insecticides (Wallner, 1978; Johnson, 1982). Because of the wax covering the insect's body, many insecticides are ineffective. In some cases only the crawler stage (the active first instar of a scale insect) may be killed, therefore the insecticide must be applied at a specific time in the life cycle of the pest. Another problem with the use of insecticides is public concern for health and environmental quality. In addition, armoured scales appear to have developed resistance to many pesticides. Traditional control measures, especially chemical control, failed to stop losses caused by armoured scales. The only way to reinstate the natural balance is to minimize the use of chemical insecticides and increase the population of natural enemies to play their role in minimizing pest populations (Rodrigo & Garcia, 1992; Kasim, 1995). Indigenous biological control agents (parasitoids and predators) provide an opportunity for significant control of armoured scale insects (Rosen, 1986).The species of *Aphytis* Howard (Hymenoptera: Aphelinidae) develop exclusively as primary ectoparasitoids of armoured scale insects, and are the most important natural enemies of these pests. Several species of this large cosmopolitan genus have been successfully employed in highly effective biological control projects, directed against various armoured scale insect pests (Rosen & DeBach, 1978, 1979). *Aphytis* spp. are tiny yellow wasps (female length 0.60–1.4 mm, male length 0.5–1.1 mm) capable of short flights within a tree, or from one tree to the next (Hayat, 1994, 1998). They are very slow to spread over longer distances. Two or three adult wasps can fit on a pinhead < 2 mm in diameter, and their distinguishing features are difficult to observe without a microscope. The adult female wasp lays its eggs under the scale cover onto the body of second-instar and unmated mature female scales (Rosen & DeBach, 1986). After hatching, the developing *Aphytis* larvae feed on the scale insects, ultimately killing them. The next generation of *Aphytis* emerges about 3 weeks later to mate and continue the cycle. Adult wasps also use scales as a food source, killing them by direct feeding (Heimpel *et al.*, 1997). Several species of *Aphytis* have been successfully employed in biological control projects directed against economically important pest species in various parts of the world (Rosen & DeBach, 1979; Basheer, 1990; Moustafa, 1995; El-Dash *et al.*, 1997). *Aphytis lepidosaphes*, *A. melinus* and *A. lingnanesis* have been widely used as biological control agents in the EPPO region (EPPO, 2012). In Bulgaria, according to Basheer (1990), *Aphytis proclia* is an active parasitoid of San Jose scale *Quadraspidiotus perniciosus*. Furthermore, *A. maculicornis* and *A. hispanicus* are the most common parasitoids on *Parlatoria oleae* (olive scale) and *Parlatoria pergandii* (chaff scale) respectively (Erler & Tunç, 2001). In Australia, according to Broadley & Thomas (1995), *A. lingnanensis* and *A. melinusare* are the main parasitoids of *Aspidiotus nerii* (oleander scale) in several Mediterranean countries

(Karaca *et al.*, 1999). Some studies have reported that *A. chilensisis* is one of the parasitoids of armoured scales in several Mediterranean countries (Lo Pinto *et al.*, 2004). Studies in Egypt have reported that *A. lepidosaphesis* is one of the most important parasitoids of *Lepidosaphes beckii* (purple scale) (Abbas, 1992; Moustafa, 1995). In Lebanon *A. chrysomphali* is the main parasitoid of *Chrysomphalus aonidum* (Florida red scale) (Traboulsi, 1969). In Syria, *A. chrysomphali* and *A. maculicornisare* are parasitoids of *A. aurantii* and olive scale respectively (Basheer, 1999; Basheer & Mahmalji, 2006). The main objective of this study was to survey the parasitoids of the genus *Aphytis* associated with armoured scale on Lattakia Citrus in Syria. This paper is not a systematic study and complete synonymies, detailed descriptions, or diagnostic morphologic illustrations have not been included. Furthermore, the cited species have not been biologically verified by breeding experiments as is frequently done (DeBach, 1960). The authors recognized the forms as morphological and biological entities in their association with armoured scale insects on Lattakia citrus trees. To facilitate identification of the species, keys to the adults and pupae and a table of diagnostic characters are included.

Materials and methods

A survey of the common *Aphytis* spp. parasitoids was carried out at four citrus orchards (in which no insecticides have been applied for the last 5 years) in AL-hanade, Stamo, Tarjano and Hmaiem in Lattakia Governorate from September 2010 to September 2011. Five citrus trees, similar in age, size, shape and growth condition, were randomly chosen for sampling at a weekly intervals for each location. Each sampling consisted of the collection of 50 infested leaves (10 leaves were collected randomly from different sides (north, south, east, west and centre) of the trees (two leaves/side), Thereafter, the leaves were kept in a closed paper bags and transferred to the laboratory for further examination. Each leaf was stored in a well-ventilated glass emergence tube and monitored daily for parasitoid emergence. The parasitoids were sorted and stored for identification. In the laboratory, some of the scales covering armoured scale insects were lifted to reveal pupa, the pupae were examined under binocular microscope to point morphology of pupa. Identification of specimens to genus level and to the species level was based on keys (Rosen & DeBach, 1979; Hayat, 1994).

Results

Six parasitoid species of the genus *Aphytis* were reared from living armoured scale insects isolated by the authors in four states. These parasitoids are *Aphytis lepidosaphes* (Compere), *Aphytis lingnanesis* (Compere), *Aphytis chrysomphali* (Mercet), *Aphytis melinus* (DeBach), *Aphytis maculicornis* (Masi) and *Aphytis hispanicus* (Mercet). The authors provide a key below for the identification of the known species from Lattakia and also give brief synopsis of the hosts and plants from which these parasitoids were collected. Morphological terminology follows the terms of Hayat (1998). Studies in Syria have recorded that *A. maculicornis, A. hispanicus* and *A. lepidosaphes* are the most important parasitoids of *P. olea* in Qunaetera and Daraa Governorates – Southern of Syria, whereas *A. melinus*, *A. chrysomphali* and *A. maculicornis* are the most important parasitoids of Oleander scale *Aspidiotus nerii* on Oleander plants in Nashabia province (Damascus countryside) (Basheer *et al.*, 2010).

Key for identification of adults of *Aphytis* spp. in citrus orchards in Lattakia

1. Propodeal crenulae large and overlapping,	Go to 2
Propodeal crenulae minute or large but not overlapping,	Go to 3
2. Thoracic sterna dusky; apical antennal segment 2.5–3.0 times longer than wide,	*A. lingnanensis* (Compere)
3. Propodeal crenulae large and distinct; head, thorax and abdomen with dark markings,	*A. hispanicus* (Mercet)
Propodeal crenulae small and indistinct; head, thorax and abdomen clear yellow, at most thoracic sterna dusky	Go to 4
4. Small species; mesosternal keel dark; 10 (rarely 12) mesoscutal setae; males rare	*A. chrysomphali* (Mercet)
Large species; thorax and abdomen yellow, club, thorax suture and abdomen angle are black, eyes are green, forewing with dark markings, males common	*A. maclicornis* (Masi)
Large species; all thoracis sterna faintly dusky 10–15 (rarely 10) mesoscutal setae; males common	*A. lepidosaphes* (Compere)
5. Ovipositor shaft usually more than 1.75 times as long as middle tibia; Ovipositor sheath usually 0.50 times, or more, as long as middle tibia; forewing usually with 39–47 setae in delta area	*A. melinus* (DeBach)

Key for identification of pupae of *Aphytis*in citrus orchard in Lattakia

1. Pupae with distinct dark marking on Venter of abdomen	Go to 2 and 3
Pupae with no dark markings on venter of abdomen	Go to 5
	A. Melinus (DeBach)

(continued)

Table *(continued)*

2. Pupae with blackish thoracic sterna, no melanization on abdomen	
3. Abdomen with lateral dark spots; head and thoracic segments also with dark areas	*A. hispanicus (*Mercet)
Abdomen with a median dark blotch or stripe; thoracic venter also dark	Go to 4
4. Dark markings on abdomen distinct on posterior segments	*A. lepidosaphes* (Compere)
Dark markings on abdomen absent	*A. maclicornis* (Masi)
5. Pupae small and pale yellow; sometimes with a narrow dark keel on mesothoracic sternum	*A. chrysomphali* (Mercet)
Pupae large and yellow except for faintly to distinctly dusky pro-, meso- and meta thoracic sterna	*A. lepidosaphes* (Compere)

Diagnostic characters

Aphytis chrysomphali (Mercet)

Adult females are clear pale yellow with at most a narrow, dark keel on the mesothoracic sternum, Thoracic setae dusky to pale and less distinct at 120 × magnification, Mesoscutum 10 setae, apex of mandibles is brown blush. Propodeum shorter in length than thorax. Length of female 0.6–0.9 mm mean 0.78 mm. Males, which are rare, have the venter of the abdomen clear. Pupae are a clear pale yellow with slightly dusky wing pads; many specimens have a narrow dark keel on the mesothoracic sternum. Isolated specimens of this parasite have been reared from Purple scale *Lepidosaphes beckii* (Newman), California red scale *Aonidiella aurantii* (Maskell) and Chaff scale *Parlatoria pergandii* Comstock. The species was reared only from second larval stage and immature females. It has been collected from all citrus orchards studied in all seasons of the year *Aphytis chrysomphali* was invariably present and was a critical factor in the control of scale insect in all study locations.

This uniparental, nearly cosmopolitan species was originally described by Mercet (1912) from specimens obtained from *Chrysomphalus dicyyospermi* var. *pinnulifera* in Spain. *C. pinnulifera* (Maskell) is now regarded as a distinct species, but the original host of *chrysomphali* may in fact have been the dictyospermum scale, *C. dictyospermi* (Morgan) (Traboulsi, 1969; Rosen & DeBach, 1979). Compere (1955) redescribed it from material reared from the California red scale *Aonidiella aurantii* (Masksll), in California.

Aphytis hispanicus (Mercet)

Body is dusky yellow with a dark transverse bar on the occiput on either side of the foramen, dark spots on the thoracic terga, and dark lateral spots on the abdominal segments. The tibia and the end of femur are dusky yellow. The club is black. There are 9–10 setae under marginal vein. No males of this species have been collected. Pupae are yellow with dark spots and bars as in the adult and dusky wing pads. Isolated specimens of this parasite have been reared from Chaff scale *Parlatoria pergandii* Comstock. The species was reared from the second larval instar stage and immature females. It has been collected from all citrus orchards studied in all seasons of the year, but is most abundant in the autumn. *Aphytis hisbanicus* was not a critical factor in the control of armoured scale.

Aphytis lepidosaphes (Compere)

Adult females are pale yellow to yellow with the thoracic sterna narrowly dusky. Antenna 6 segemented, all thoracic sterna faintly dusky 10–15 (rarely 10) mesoscutal setae. Males are common. Pupae are pale yellow except for dusky wing pads and a faint to distinct, narrow duskiness on the thoracic sterna. The parasite has been recovered during all seasons and in all study areas. In addition to the major host, specimens of *A. lepidosaphes* have been reared from Purple scale *Lepidosaphes beckii* (Newman). The species was reared from second larval instar stage, immature females and prepupa. *Aphytis lepidosaphes* was not a critical factor in the control of armoured scale.

Aphytis lingnanesis (Compere)

Adult females are 0.68–0.73 mm in length, and 0.3–0.5 mm wide. Adult females are yellow with narrowly dusky thoracic sterna. Males are common. Pupae are pale yellow with duskiness on the margins of the thorax and at the tips of the wing pads. The Venter of the thorax, between the legs, is dark and the Venter of the abdomen is marked with a dark longitudinal bar that is wide and distinct on the anterior sternites and narrow but usually distinct on the posterior sternites. *Aphytis lingnanensis* have been reared from Purple scale *Lepidosaphes beckii* (Newman), California red scale *Aonidiella aurantii* (Maskell) and Chaff scale *Parlatoria pergandii* Comstock. The species was reared only from second larval stage and immature females. It has been collected from all citrus orchards studied in all seasons of the year. *Aphytis lingnanensis* was invariably present and was a critical factor in the control of scale insect in all study locations.

Aphytis maculicornis (Masi)

Adult females are 0.6–0.9 mm in length, and 0.35–0.5 mm wide. Adult females are yellow, thorax and abdomen yellow, club, thorax suture and abdomen angle are black, eyes are green, forewing with dark markings, males common. Pupa are yellow, dark markings on abdomen absent. Pupa are 0.58–0.6 mm length and 0.3–0.4 mm wide. *Aphytis maclicornis* have been reared from Purple scale *Lepidosaphes beckii* (Newman), California red scale *Aonidiella aurantii* (Maskell) and Chaff scale *Parlatoria pergandii* Comstock. The species was reared only from

second larval stage and immature females. It has been collected from some of citrus orchard studied in all seasons of the year, and it is most abundant in the autumn. *Aphytis macilicornis* was not a critical factor in the control of armoured scale.

Aphytis melinus (DeBach)
Adult females are 0.3–0.7 mm in length and 0.3–0.4 mm wide. Adult females are yellow and have short knobby antennae. Pupa are 0.58–0.6 mm in length and 0.28–0.4 mm wide. Pupa have blackish thoracic sterna, no melanization on abdomen. The female *A. melinus* deposits a single egg beneath the scale cover. *Aphytis melinus* have been reared from Purple scale *Lepidosaphes beckii* (Newman), California red scale *Aonidiella aurantii* (Maskell) and Chaff scale *Parlatoria pergandii* Comstock. The species was reared from second larval stage, immature females pre-pupa and pupa. It has been collected from all orchards studied in all season of the year, and was a critical factor in the control of armoured scale.

Conclusions

The survey of the parasitoid species belonging to the genus *Aphytis* attacking armoured scales in coastal areas of Syria leads the authors to conclude that these parasitoids are likely to be responsible for suppressing armoured scale and keeping it at extremely low densities in coastal areas of Syria.

The results also suggest that some of these parasitoids could be used against armoured scale in the coastal areas of Syria, either inoculatively or augmentatively by mass rearing them using Oleander scale as an insect host.

Finally, the authors recommend that more studies should be carried out to determine:

1. the effectiveness of augmentative release of *A. melinus*;
2. the distribution of *A. melinus* in Syria especially in coastal areas.

Parasitoïdes appartenant au genre *Aphytis* Howard (Hymenoptera: Aphelinidae) dans les vergers d'agrumes en Lattakia, Syria

Une enquête sur les espèces communes d'*Aphytis* spp. Howard (Hymenoptera: Aphelinidae) parasitoïdes de cochenilles a été menée dans quatre vergers d'agrumes (qui n'étaient pas traités avec des pesticides chimiques) à AL-Hanade, Stamo, Tarjano et Hmaiem dans le Gouvernorat de Lattakia entre septembre 2010 et septembre 2011. Six espèces de parasitoïdes du genre *Aphytis* ont été élevées à partir de cochenilles vivantes isolées dans les quatre lieux. Il s'agit d'*Aphytis lepidosaphes* (Compere), *Aphytis lingnanesis* (Compere), *Aphytis chrysomphali* (Mercet), *Aphytis melinus* (DeBach), *Aphytis maculicornis* (Masi) et d'*Aphytis hispanicus* (Mercet).

Паразитоиды, принадлежащие к роду *Aphytis* Howard (Hymenoptera: Aphelinidae), в цитрусовых садах в Латтакии, Сирия

С сентября 2010 по сентябрь 2011 г. в четырех садах цитрусовых (которые не обрабатывались химическими пестицидами): в Аль-Ханаде, Стамо, Таряно и Хмаеме, в губернии Латтакия, проводилось изучение паразитоидов обычных видов *Aphytis* spp. Howard (Hymenoptera: Aphelinidae). Шесть видов паразитоидов рода *Aphytis* были выведены из живых щитовок, выделенных в четырех штатах: *Aphytis lepidosaphes* (Compere), *Aphytis lingnanesis* (Compere), *Aphytis chrysomphali* (Mercet), *Aphytis melinus* (DeBach), *Aphytis maculicornis* (Masi) и *Aphytis hispanicus* (Mercet).

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