

Biological studies of the California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) under different host plants and temperatures with an annotated list of natural enemies of this pest in Egypt

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ABSTRACT

The California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) is potentially a severe pest of citrus trees in different parts in Egypt. The aim of this work is to study the biological studies of this pest on the host plants, *Citrus sinensis* (citrus), *Ficus nitida* (laurel fig) and *Mangifera indica* (mango) under different temperatures (18, 24, 30°C) as well as an annotated list of natural enemies associated with *A. aurantii* in Egypt. The results observed the host plants and temperatures greatly influenced on the development of *A. aurantii*. The lowering of the temperature increased the dimension of the California red scale and lengthened the developmental period. The results on host plants, citrus, *Ficus nitida* and mango showed that the life cycle of *A. aurantii*, at 30°C were 49.8±11.31, 68.9±19.30 and 81.3±18.31 days, respectively. These results indicated that *A. aurantii* prefers citrus followed by *Ficus nitida* and mango. Twelve species of parasitoids and nine species of predators were collected and recorded, one of them is new record and this is *Encarsia lounsburyi* (Berlese & Paoli) (Hymenoptera: Aphelinidae).

Keywords: California red scale, temperatures, annotated natural enemies, Egypt.

INTRODUCTION

The California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) occurs on host plants belonging to at least 80 plant families (El-Minshawy, 1974 and Moursi, 1991). The California red scale is one of the most important pest infested citrus trees in different parts of the world (Onder, 1982; Batra *et al.* 1987; Bozan and Yldrm, 1992; Longo *et al.* 1994; Karaca, 1998; Claps *et al.* 2001 and Abd-Rabou, 2009). This pest inserts its mouthparts deep into plant tissue and sucks sap from parenchyma cells. Saliva injected as the scales feed is very toxic to the leaves, twigs, branches and fruit of citrus trees. The leaves develop a characteristic yellow spot under and around each female scale. Prolonged infestation may cause leaf drop and defoliation and dieback of twigs and eventually large branches. Maturing fruit can become completely encrusted with scales; developing scales form prominent pits on young fruit which are still evident when the fruit matures. Such fruit tend to dry out and fall off. Even the trunk can become heavily infested (Bedford, 1998). Organophosphorus insecticides have been used commercially for the control of this pest in Egypt. Bozan and Yldrm (1992), Schoeman (1994), Charles *et al.* (1995), Karaca and Uygun (1999), Stathas (2001), Yarpuzlu *et al.* (2008) and Abd-Rabou (2009) studied the natural enemies of *A. aurantii* in different parts of the world.

The aim of this work is to study the biological studies of this pest on host plants, citrus, laurel fig and mango under different temperatures as well as an annotated list of natural enemies associated with this pest.

MATERIALS AND METHODS

1. Biological studies of the California red scale, *Aonidiella aurantii* under different host plants and temperatures:

The California red scale, *A. aurantii*: was reared on three host plants i.e. *Citrus sinensis* (citrus), *Ficus nitida* (laurel fig) and *Mangifera indica* (mango). For biological studies of *A. aurantii*, eggs and crawlers were obtained from the mother of the California red scale reared on citrus, *Ficus nitida* and mango under laboratory conditions 25-27°C, 65-75% RH and 18 hours Photoperiod. The incubation period of eggs was determined by using one day old egg of a mother of the California red scale. Fifty eggs from each host plant were spread on blotting paper in a small Petri dish. This Petri dish was in turn placed within a bigger dish containing some distilled water. The latter dish was covered with fine muslin so as to give maximum humidity to the eggs. The Petri dish containing the eggs was kept in a constant temperature incubator.

Ten replicate Petri dish for each plant were kept at the following temperatures: 18, 24 and 30°C. The procedure for determining egg viability was, similar to that of egg incubation. Fifty eggs from each host plant were kept in each Petri dish at the following temperatures: 18, 24 and 30°C. Four replicate of Petri dish for host each were kept at each temperature regime. The eggs were observed daily with a stereomicroscope (X 15) for the emergence of the crawlers. For studying the development of the California red scale on citrus, *Ficus nitida* and mango washed with clean water. Newly emerged crawlers were transferred from the mother scale on to the leaves of citrus, *Ficus nitida* and mango using a fine paint brush. Each pot was infested with 100 crawlers. The infested pot was then kept in a ventilated polystyrene box (175 mm X 115 mm X 52mm). Two boxes were kept at each of the temperatures used in the study. Twenty individuals of the California red scale exposed at each of the various constant temperatures were selected at random for studying their development. The development of the individuals the California red scale was observed daily using a stereomicroscope (x 15).

The obtained data of the biological studies were analyzed following Birch (1948) using Life 48 Basic Computer Program (Abou-Setta *et al.*, 1986).

2. Natural enemies of the California red scale *Aonidiella aurantii*:

Infested crops with, *A. aurantii* will be examined in the field, using a pocket lens during 2008-2010. The parts of the plant from different crops will be collected and placed separately in paper bags for further examination in the laboratory. Materials will be kept in a well-ventilated container until the emergence of any parasitoids. Identification of parasitoids will be made by examining mounted adults in Hoyers medium according to the methods of (Abd-Rabou, 2002a). In the other hand a survey of the predators of *A.aurantii* was carried out in different locations in Egypt during 2008-2010. Infested host plants by the red scale, *A. aurantii* was examined in the field, using a pocket lens. Leaves, leaflet, stems and fruits from different host plants were collected and placed separately in paper bags for further examination in the laboratory. Predators were made by examining their mounted adults on cards according Noyes (1982).

RESULTS AND DISCUSSION

1. Biological studies of the California red scale, *Aonidiella aurantii* under different host plants and temperatures:

1.1. Biological studies of the California red scale, *Aonidiella aurantii* on citrus trees:

The biological parameters of the California red scale, *A. aurantii* at three different constant temperatures (i.e. 18, 24 and 30°C) on citrus are presented in Table (1). Mean

durations of the first instar were 7.2 ± 0.26 , 4.9 ± 0.24 and 3.7 ± 0.26 days at 18, 24 and 30°C , respectively. Second instar lasted for 10.1 ± 0.16 , 8.2 ± 0.26 and 6.3 ± 0.59 days, respectively. While third instar durations were 12.7 ± 0.58 , 10.7 ± 0.26 and 6.9 ± 0.91 , respectively. Incubation periods were 4.7 ± 0.63 , 2.9 ± 0.34 and 1.7 ± 0.26 days, respectively. The generation period was 81.5 ± 15.20 , 66.2 ± 13.15 and 49.8 ± 11.31 days, respectively. The durations of the adult longevity were 51.5 ± 2.42 , 42.4 ± 1.96 and 32.9 ± 2.23 days, respectively (Table, 1). These results indicated that 30°C was the most adequate tested temperature for the California red scale, *A. aurantii* life resulting the highest oviposition (143.9 ± 2.92 eggs/female), the shortest incubation period (1.7 ± 0.26 days) and adult longevity (32.9 ± 2.23 days).

Table 1: Average duration (in days) of the California red scale *Aonidiella aurantii* stages at three constant temperatures (18, 24 and 30°C) on citrus.

Developmental stages	Duration (in days)		
	Mean \pm SE at 18°C	Mean \pm SE at 24°C	Mean \pm SE at 30°C
Egg incubation period	4.7 ± 0.63	2.9 ± 0.34	1.7 ± 0.26
1 st instar	7.2 ± 0.26	4.9 ± 0.24	3.7 ± 0.26
2 nd instar	10.1 ± 0.16	8.2 ± 0.26	6.3 ± 0.59
3 rd instar	12.7 ± 0.58	10.7 ± 0.26	6.9 ± 0.91
Total instars period	30.0 ± 0.72	23.8 ± 0.66	16.9 ± 0.61
Adult longevity	51.5 ± 2.42	42.4 ± 1.96	32.9 ± 2.23
Total average of eggs/female (fecundity)	89.3 ± 4.85	118.7 ± 4.76	143.9 ± 2.92
Adult's lifespan	81.5 ± 15.20	66.2 ± 13.15	49.8 ± 11.31

1.2. Biological studies of the California red scale, *Aonidiella aurantii* on laurel fig:

The biological parameters of the California red scale, *A. aurantii* at three different constant temperatures (i.e. 18, 24 and 30°C) on *Ficus nitida* are presented in Table (2). Mean durations of the first instar were 9.4 ± 0.24 , 7.3 ± 0.24 and 5.7 ± 0.57 days at 18, 24 and 30°C , respectively. Second instar lasted for 12.3 ± 0.26 , 11.1 ± 0.37 and 10.0 ± 0.47 days, respectively. While third instar durations were 13.5 ± 0.62 , 12.7 ± 0.77 and 11.0 ± 0.65 , respectively. Incubation periods lasted 7.1 ± 0.37 , 6.3 ± 0.24 and 5.1 ± 0.42 days, respectively. The generation period was 89.9 ± 22.84 , 80.3 ± 21.85 and 68.9 ± 19.30 days, respectively. The durations of the adult longevity were 61.1 ± 1.29 , 55.6 ± 0.52 and 48.1 ± 1.10 days, respectively (Table, 2). These results indicated that 30°C was the most adequate tested temperature for the California red scale, *A. aurantii* showing the highest oviposition (104.1 ± 2.56 eggs/female), the shortest incubation period (5.1 ± 0.42 days) and adult longevity (48.1 ± 1.10 days).

Table 2: Average duration (in days) of the California red scale *Aonidiella aurantii* stages at three constant temperatures (18, 24 and 30°C) on *Ficus nitida*.

Developmental stages	Duration (in days)		
	Mean \pm SE at 18°C	Mean \pm SE at 24°C	Mean \pm SE at 30°C
Egg incubation period	7.1 ± 0.37	6.3 ± 0.24	5.1 ± 0.42
1 st instar	9.4 ± 0.24	7.3 ± 0.24	5.7 ± 0.57
2 nd instar	12.3 ± 0.26	11.1 ± 0.37	10.0 ± 0.47
3 rd instar	13.5 ± 0.62	12.7 ± 0.77	11.0 ± 0.65
Total instars period	28.8 ± 2.61	24.7 ± 2.53	20.8 ± 2.67
Adult longevity	61.1 ± 1.29	55.6 ± 0.52	48.1 ± 1.10
Total average of eggs/female (fecundity)	82.4 ± 2.07	92.7 ± 1.77	104.1 ± 2.56
Adult's lifespan	89.9 ± 22.84	80.3 ± 21.85	68.9 ± 19.30

1.3. Biological studies of the California red scale, *Aonidiella aurantii* on mango trees:

The biological parameters of the California red scale, *A. aurantii* at three different constant temperatures (i.e. 18, 24 and 30°C) on mango are presented in Table (3). Mean durations of the first instar were 11.2±0.26, 10.2±0.41 and 6.3±0.34 days at 18, 24 and 30°C, respectively. Second instar lasted 15.5±0.43, 12.5±0.45 and 10.4±0.16 days, respectively. While third instar durations were 16.8±0.45, 15.1±0.79 and 11.0±0.51, respectively. Incubation periods were 10.3±0.24, 9.0±0.53 and 6.0±0.55 days, respectively. The generation period was 113.1±18.46, 101.0±17.96 and 81.3±18.31 days, respectively. The durations of the adult longevity were 69.6±1.79, 63.2±2.45 and 53.6±1.23 days, respectively (Table, 3). These results indicated that 30°C was the most adequate tested temperature for the California red scale, *A. aurantii* life showing the highest oviposition (96.7±1.42 eggs/female), the shortest incubation period (6.0±0.55 days) and adult longevity (53.6±1.23 days).

Table 3: Average duration (in days) of the California red scale *Aonidiella aurantii* stages at three constant temperatures (18, 24 and 30°C) on mango.

Developmental stages	Duration (in days)		
	Mean ± SE at 18°C	Mean ± SE at 24°C	Mean ± SE at 30°C
Egg incubation period	10.3±0.24	9.0±0.53	6.0±0.55
1 st instar	11.2±0.26	10.2±0.41	6.3±0.34
2 nd instar	15.5±0.43	12.5±0.45	10.4±0.16
3 rd instar	16.8±0.45	15.1±0.79	11.0±0.51
Total instars period	43.5±2.93	37.8±2.45	27.7±2.56
Adult longevity	69.6±1.79	63.2±2.45	53.6±1.23
Total average of eggs/female (fecundity)	74.0±2.05	85.8±3.52	96.7±1.42
Adult's lifespan	113.1±18.46	101.0±17.96	81.3±18.31

In the present work, the host plants and temperatures greatly influenced the development of *A. aurantii*. Karaca (1998) and Claps *et al.* (2001) stated that, there is a close correlation between temperature and development. The lowering of the temperature increased the dimension of the red scale and lengthened the development period. The results on citrus, *Ficus nitida* and mango trees showed that the life cycle of *A. aurantii* at 30°C were 49.8±11.31, 68.9±19.30 and 81.3±18.31 days, respectively. These results indicated that *A. aurantii* prefers citrus followed by *Ficus nitida* and mango. The results of the present work agree with the findings of the laboratory work of the biology of *A. aurantii* are given by Quayle (1941) and Ebeling (1959).

2. Annotated list of natural enemies of the California red scale, *Aonidiella aurantii* in Egypt

2.1. Parasitoids:

Twelve species of parasitoids were collected and associated with of *A. aurantii* these are:

I. Aphelinidae

1. *Phytis africanus* Quednau

Material Examined: 10 ♀♀, 13 ♂♂, North Sinai (El-Arish), 1.VI .2008 ex. *A. aurantii*.

2. *Aphytis azai* Abd-Rabou

Material examined: 5 ♀♀, 3 ♂♂, El-Minya, 10. V. 2009, ex. *A.aurantii* on *Citrus* sp.

3. *Aphytis chrysomphali* (Mercet)

Material Examined:, 6♀♀, Gharbiya, 10.XI.2008, ex. *A. aurantii* on *F. nitida*.

4. *Aphytis lingnanensis* Comepre

Material Examined: 8 ♀♀, 9 ♂♂, Giza, 10. X. 2010 ex. *A. aurantii* on *Citrus* sp.

5. *A. sinaii* Abd-Rabou

Material Examined: 7 ♀♀, 2 ♂♂, South Sinai 9.V. 2009 ex. *A. aurantii* on *F. nitida*.

6. *Coccobius* sp.

Material Examined: 8 ♀♀, El-Minya, 13.IV.1020 ex. *A. aurantii* on *Citrus* sp.

7. *Encarsia aurantii* (Howard)

Material Examined: 25 ♀♀, Northern Coast, 4.III. 2010, ex. *A. aurantii* on *Olea* sp.

8. *Encarsia citrina* (Craw)

Material Examined: 15 ♀♀, Dokki (Giza), 25. IX. 2010, ex. *A. aurantii* on *Citrus* sp.

9. *Encarsia lounsburyi* (Berlese & Paoli)

Material Examined: 23 ♀♀, El-Minya, 11. X. 2009, ex. *A. aurantii* on *Citrus* sp.

10. *Marietta leopardina* Motschulsky

Material Examined: 13 ♀♀, Giza, 5. VI. 2008, ex. *A. aurantii* on *F. nitida*.

11. *M. picta* (Andre)

Material Examined: 14 ♀♀, Alexandria, 12. V. 2008, ex. *A. aurantii* on *Citrus* sp.

II. Encyrtidae**12. *Habrolepis aspidioti* Compere & Annecke**

Material examined: 20 ♂♂, 12 ♂♂, Qalyubiya, 15. VII. 2009, ex. *A. aurantii* on *Citrus* sp.

13. *Habrolepis rouxi* Compere

Material examined: 7 ♂♂, 5 ♂♂, Qalyubiya, 12. VI. 2009, ex. *A. aurantii* on *F. nitida*

2.2. Predators:

Nine species of predators were collected and associated with of *A. aurantii* these are:

I. Coleoptera:**Family: Coccinellidae****1. *Chilocorus bipustulatus* L.**

Material examined: 15 individuals, Giza, 15. VII. 2009, ex. *A. aurantii* on *F. nitida*

2. *Coccinella undecimpunctata* L

Material examined: 11 individuals, Giza, 10. VI. 2009, ex. *A. aurantii* on *Ficus nitida*

3. *Exochomus flavipes* Thunb.

Material examined: 8 individuals, Giza, 4. III. 2010, ex. *A. aurantii* on *F. nitida*

4. *Pharoscyrnus varius* Kirsch

Material examined: 18 individuals, Marsa Matruh , 19. VII. 2009, ex. *A. aurantii* on *Ficus carica*

5. *Rodalia cardinalis* Muls

Material examined: 4 individuals, Marsa Matruh , 10. VI. 2008, ex. *A. aurantii* on *F. carica*

6. *Scymnus syriacus* Mars.

Material examined: 7 individuals, Beni-Suef, 8. VII. 2010, ex. *A. aurantii* on *Citrus* sp.

II. Diptera:**Family: Syrphidae****7. *Syrphus corollae* Fab.**

Material examined: 13 individuals, Marsa Matruh, 6. VI. 2009, ex. *A. aurantii* on *F. carica*

III. Hemiptera**Family: Anthocoridae****8. *Orius laevigatus* Fieb.**

Material examined: 19 individuals, Marsa Matruh, 18. VII. 2009, ex. *A. aurantii* on *F. carica*.

IV. Neuroptera**Family: Chrysopidae****9. *Chrysoperilla carnae* Steph. Giza Governorate *F. nitida***

Material examined: 26 individuals, Giza, 17. VI. 2010, ex. *A. aurantii* on *F. nitida*.

In the present work 12 species of parasitoids (10 species belonging to Family Aphelinidae and the rest of species belonging to Family Encyrtidae) and 9 species of predators (6 species belonging to Family: Coccinellidae, one species belonging to

Family: Anthocoridae, one species belonging to Family Chrysopidae and one species belonging to Family: Syrphidae) were identified and collected associated with *A. aurantii*. In this respect, many workers recorded and collected the natural enemies of this pest in Egypt for example: Priesner & Hosny (1940), Hafez (1988), Abd-Rabou (1999,2001, 2002b and 2004a,b) and Abd-Rabou and Hayat (2003),

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ARABIC SUMMARY

الدراسات الحيوية للحشرة القشرية الحمراء مع قائمة بالأعداء الحيوية لهذه الآفة في مصر

هدى بدارى - شعبان عبدربه

معهد بحوث وقاية النباتات - مركز البحوث الزراعية- الدقي- الجيزة- مصر

الحشرة القشرية الحمراء من أهم الآفات التي تصيب الموالح في مصر. تم في هذا العمل اجراء الدراسات البيولوجية لحشرة القشرية الحمراء بالإضافة قائمة بالأعداء الحيوية لهذه الآفة في مصر. وقد أتضح من النتائج أن أختلاف درجة الحرارة و العائل النباتي يؤثر تأثيرا بالغا على تطور الحشرة القشرية الحمراء ومن خلال النتائج أيضا أتضح أن دورة حياة الحشرة على ثلاث نباتات (الموالح و الفيكس نيبيدا و المانجو) عند درجة مئوية ٣٠ كانت 49.8 ± 11.31 , 68.9 ± 19.30 , 81.3 ± 18.31 أيام على الترتيب ومن هنا يتضح ان الحشرة القشرية الحمراء تفضل الموالح عن الفيكس نيبيدا ثم المانجو. وقد أشارت النتائج أيضا الحشرة القشرية الحمراء مصاحبة ب ١٢ طفيل و ٩ مفترسات تم تسجيل احد هذه الأنواع لأول مرة في مصر وهي أنكارسيا ليونزبرى.