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Population dynamics and seasonal trend of California red scale (*Aonidiella aurantii* Maskell) in citrus in Northern Spain

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Abstract

The California red scale, *Aonidiella aurantii* (Maskell), was first detected in citrus groves in Catalonia, Northern Spain, in 2000, and has since spread slowly and irregularly. New foci of infestation are currently found in citrus-growing areas of southern Tarragona. As Catalonia is the northernmost citrus growing area in Spain, between 2002 and 2009, *A. aurantii* population dynamics and seasonal trends were studied in two citrus groves and compared with other regions and countries. The population dynamics showed that there were four male flights (including that of the overwintering generation): in May, mid June-mid July, August and October, the most abundant being that of August (over 60% of the males captured during the year). The thermal constant estimated between male flights, using 11.7°C as the lower threshold temperature, was 611.8 ± 35.5 degree-days. Three peaks of 1st and 2nd nymph instars were observed: in early June, late July-early August, and late September. The number of crawlers captured on sticky tapes reached a first maximum on 27th May (± 1.85 days). The male flight abundance showed a positive relationship between two consecutive generations, revealing the stability of *A. aurantii* populations.

Additional key words: *Aonidiella aurantii*; California red scale; Catalonia; Diaspididae; population dynamics.

Resumen

Dinámica poblacional y estacional del piojo rojo de California (*Aonidiella aurantii* Maskell) en cítricos del norte de España

El piojo rojo de California, *Aonidiella aurantii* (Maskell), fue detectado en el año 2000 en Cataluña, y desde entonces hasta la actualidad esta plaga ha experimentado una lenta e irregular expansión; actualmente se pueden encontrar focos de infestación de la plaga en todas las áreas de cultivo citrícolas del sur de Tarragona. En la zona citrícola de Cataluña, que es la más septentrional de España, desde 2002 a 2009, se llevaron a cabo estudios del ciclo biológico y vuelos de machos en dos fincas de cítricos para compararlos con otras regiones y países. De acuerdo con la dinámica poblacional observada, se produjeron cuatro vuelos de machos (incluyendo el de las poblaciones invernantes): en mayo, desde mediados de junio a mediados de julio, en agosto y durante octubre, siendo el tercero el más abundante, que representa alrededor del 60% del total de machos capturados. La constante térmica estimada entre dos vuelos consecutivos, empleando como umbral mínimo 11,7°C, fue de 611,8 ± 35,5 grados-día. Además se observaron tres máximos de ninfas de primera y segunda edad: a primeros de junio, entre finales de julio y primeros de agosto, y a finales de septiembre. El número de ninfas móviles de primera edad alcanzó un primer máximo el 27 de mayo (± 1,85 días). La abundancia de machos en los vuelos mostró una relación positiva entre vuelos consecutivos, mostrando la estabilidad de las poblaciones de *A. aurantii.*

Palabras clave adicionales: *Aonidiella aurantii*; Cataluña; Diaspididae; dinámica poblacional; piojo rojo de California.

Introduction

Throughout the world, the California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae), is considered the most harmful Diaspididae in citrus groves, where it is difficult to control and causes major economic losses. Although *A. aurantii* was first reported in Spain over 70 years ago (Gómez-Menor, 1937), it did not achieve pest status until 1985, when a focus was detected in Alzira, Valencia (Alfaro-Lassala

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Abbreviations used: DD (degree-days); IGR (insect growth regulators); N1 (first instar nymph); N1m (first instar molt); N2 (second instar nymph); N2m (second instar molt); H1 (third instar female); H2 (gravid female); H3 (reproducing female).

et al. 1999a). Just two years later, it was also detected in Andalucía, in the provinces of Huelva, Sevilla and Cadiz. In 1989, there were serious attacks in the area that had been initially infested, where —despite chemical treatment— high losses occurred were registered during harvest. By 2003, *A. aurantii* had colonised the citrus-growing areas of Valencia province and northern Alicante to different degrees, while in Castellón, it had spread from the original focus detected in 1999 (Alfaro-Lassala *et al.,* 2003). It has now spread from its initial focus in the centre of Valencia province, but it is not as prevalent in the northern and southern parts of the region and is absent from northern areas of Castellón (CAPA, 2009). In Valencia, *Aonidiella aurantii* seems to have a climatic preference for coastal and southern areas, as population maximums are found in the areas where it was first detected (CAPA, 2009). It is now also present throughout Andalucía, and particularly in Huelva (González-García, 2009), where *A. aurantii* is the major pest affecting citrus groves. It was also detected in Majorca, in 2007, where its spread has been favoured by the abandonment of citrus groves (Rosselló & Olmo, 2009).

In 2000, this species was detected in Tarragona province when the IRTA Estació Experimental de l'Ebre (Ebro Research Station) identified it in a clementine (*Citrus reticulata* Blanco cv. Clemenules) sample from Sta. Barbara (Tarragona) (Martínez-Ferrer, personal observation). New foci of infestation have progressively appeared, slowly and irregularly, throughout the surrounding citrus-growing areas and also in other parts of Spain.

Studies conducted in Valencia revealed that *A. aurantii* has three generations per year (Ripollés, 1990; Rodrigo & Garcia-Marí, 1992), while in Andalucía, three or four generations can be found, depending on the province (CAP, 2009). Since first and second instar nymphs (N1 & N2) are the most sensitive to pesticides, due to their thin shield, chemical control is recommended when peaks of both instars are observed (Ripollés, 1990; Rodrigo & Garcia-Marí, 1992; Alfaro-Lassala *et al.,* 1999b), especially in the first generation (Alfaro-Lassala *et al.,* 1999b; Hernández-Penadés *et al.,* 2004). It is therefore necessary to study its seasonal trends. The pesticides authorised for use in Integrated Pest Management Programmes for Citrus-Production in Catalonia are chlorpyrifos, buprofezin, pyriproxyfen, chlorpyrifos-methyl and petroleum oil sprays (DAR, 2009). Among the potential drawbacks of controlling *A. aurantii* using chemicals are their resistance to organophosphates such as chlorpyrifos (Grafton-Cardwell & Vehrs, 1995; Martínez-Hervás *et al*., 2006) and *Icerya purchasi* outbreaks due to the abuse of insect growth regulators (IGR), such as pyriproxyfen; as occurred in California (Grafton-Cardwell, 1998). Efforts are currently being focused on disrupting mating behaviour (Lucas *et al*., 2009;Vacas *et al*., 2009) and on improving biological control by increasing *Aphytis* populations, by introducing endoparasitoid species (Pina, 2006), or by adopting combined strategies and also spraying with oils (Urbaneja *et al*., 2008).

Catalonia is the northernmost citrus growing area in Spain. Our aim was to study the dispersal of this emergent pest, its population dynamics and seasonal trend patterns in order to compare them with other regions and countries and to thereby improve the management of *A. aurantii* in our region.

Material and methods

Dispersal in Northern Spain

From 2000 onwards, pest control advisers from local citrus grower-exporter industries have called for action to identify citrus groves that have been recently infested by *A. aurantii*. During a 9-yr period, the interested parties provided *A. aurantii*-infested samples in order to confirm the presence of the insect. Samples of infested fruits, leaves, twigs and branches were taken to the laboratory and *A. aurantii* individuals were identified under a stereomicroscope, according to Ben-Dov (1990).

Population dynamics. Male flights

The trials were conducted in the south of Tarragona province (Spain) at two sites located near Tortosa and Sta. Barbara. The Tortosa grove was located on the banks of the Ebro river (40° 46'52.12'' N; 0° 31'22.47'' E; altitude 3 m); the trees were 20-25 yr-old, late-maturing, Valencia *Citrus sinensis* Osbeck and were spaced 4.5 × 5 m. The Sta. Barbara grove (40° 44'29.73'' N; 0° 28'22.88'' E; altitude 50 m) was a 10-12 yr-old Navelina *Citrus sinensis* Osbeck grove, with a 4 × 5.5 m spacing. The corners of both groves were selected for study, with the Valencia grove containing 190 trees (4,300 m^2) and the Navelina grove containing 260 trees (5,900 m^2). Both groves used drip-line irrigation systems, and during the sampling period, no insecticides were applied except for aphids.

The flights of *A. aurantii* males were determined in Tortosa (between 2002 and 2009) and Sta. Barbara (between 2002 and 2004). Temperature was recorded with a temperature and relative humidity datalogger (HOBO® H8 Pro Series Onset Computer Corp. Cape Cod, USA), which was placed within the canopy of one of the trees in each grove. The climate in both of the areas sampled was typically Mediterranean, with average daily minimum and maximum temperatures of 21 and 27°C, respectively, during the summer months, and of 7 and 12°C, respectively, in winter (Fig. 1).

A yellow sticky trap with *A. aurantii* Scenturion Lure® (Suterra LLC, Bend,. Oregon, USA) pheromone dispensers were hung in six trees affected by medium-heavy *A. aurantii* infestation. The traps consisted of a rectangular (11 × 10 cm) sheet of glass that was sprayed with Soveurode® (Scotts-Biosystemes, France): an aerosol glue, on a weekly basis, and then mounted in a wooden case. The traps were placed at a height of 1.5-2 m above ground and spaced at least 20 m apart. The pheromone dispensers were replaced every 45 days. On a weekly basis from April to September and on a fortnightly basis for the rest of the year, the number of *A. aurantii* males caught per trap was counted under the stereomicroscope.

The lower threshold temperature used for studying the degree-day (DD) accumulation was 11.7°C (Kennett & Hoffman, 1985; Grout *et al.,* 1989; University of California, 1991). The date with the highest value for each flight was considered the median interval that defined the beginning and end of each flight. In other words, the number of males accumulated since the beginning of the flight was 50% of the total number of males captured within a flight. We chose the median value as the parameter for calculating the distance in degree-days between different male flights, because the coefficient of variation was lower than that obtained by applying other approaches, such as selecting samples at the beginning or the peak of each flight.

Seasonal trend

The seasonal trend study was carried out on green twigs (0-1 yr-old) and branches (1-2 yr-old). Infested twigs and branches (30-40 samples) from heavily infested trees were collected and cut into 10-15 cm pieces in the laboratory. The different live instars (N1, first instar nymph; N1m, first instar molt; N2, second instar nymph; N2m, second instar molt; H1, third instar female; H2, gravid female; H3, reproducing female; second instar male; prepupa; pupa and adult male) were indentified under a stereomicroscope. The number of each instar found was recorded. The observation for each sampling date ended once the number of adult females (H1, H2 plus H3) recorded reached 100.The sampling period was once a fortnight from mid February until late April, and once a week until late October in 2006; it was once a week from mid-January until late October in 2007 and also from mid-April until early November 2009 and then once a fortnight until mid-December in 2009. Crawler emergence was also monitored following the method used in California to detect crawler generations (University of California, 1991). Thus, in four trees with medium-heavy infestations, two sticky tapes per tree were wrapped around

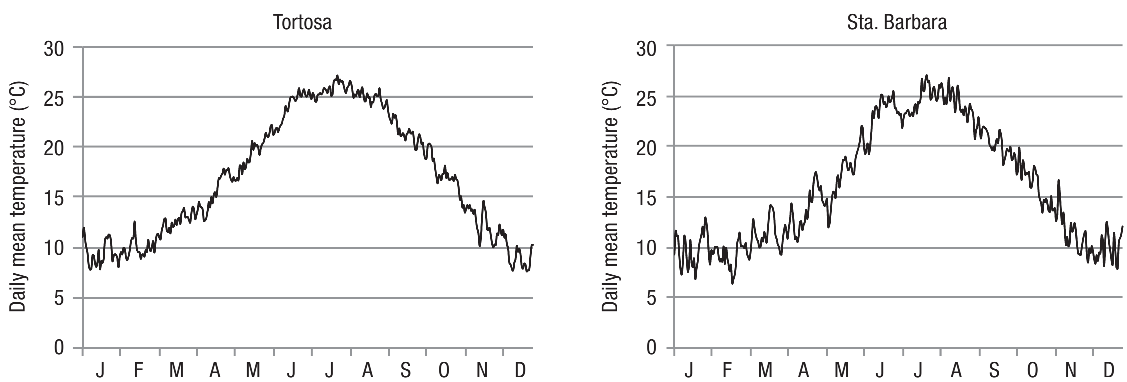

Figure 1. Mean daily temperature in Tortosa (between 2002 and 2009) and Sta. Barbara (between 2002 and 2004).

twigs on which there were live female insects. The number of crawlers caught on the tape was counted under a stereomicroscope. The sampling period was as follows: once per week from mid-April until mid-November in 2006, from mid-January until mid-October in 2007, and from mid-April until mid-August in 2009, and once per fortnight from then until early December in 2009.

Statistical analysis

Analysis of data variance was applied to the number of males per flight, using the General Linear Method (PROC GLM, SAS Inst. Inc. 2008). Means comparison was conducted using the Duncan's Multiple Range Test, with a significance level of 95%. We estimated the regression coefficient between all of the males captured in each flight in order to establish the relationship between them. Data were transformed to Ln (x + 1) prior to regression analysis, using the REG procedure (SAS Inst. Inc., 2008).

Results

Dispersal in Northern Spain

In 2009, it was found that more than twenty groves in the south of Tarragona province had been infested by *A. aurantii* since 2000 (Fig. 2). In 2000, several months after the first focus was found in Sta. Barbara, another infested grove was detected in Tortosa. In the following year, only one new infested grove was detected and no other new foci appeared for another five years (until 2006) when four new infested groves were found. Within the next two years, five new infested groves were detected, the first of which was located in the southern coastal area in 2007. Finally, in 2009, nine new infested groves were found, most of which were located in the southern area, near Alcanar. Since then, further and ever-growing foci have been identified in Alcanar; in citrus-growing areas in southern Tarragona; and in Castellón province. Most of these groves had a few infected trees with low pest populations, which generally remained undetected until harvest.

Population dynamics. Male flights

Based on the number of adults captured in traps in both groves, we generally observed four *A. aurantii* male flights (Fig. 3). The first males were captured between late March and early April. This first male flight continued until the end of May, with its peak occurring on 9th May (± 2.23 days).The second male flight was recorded was at the beginning of summer. It lasted from mid-June to mid-July and the maximum level was reached on 5thJuly (± 3.19 days).

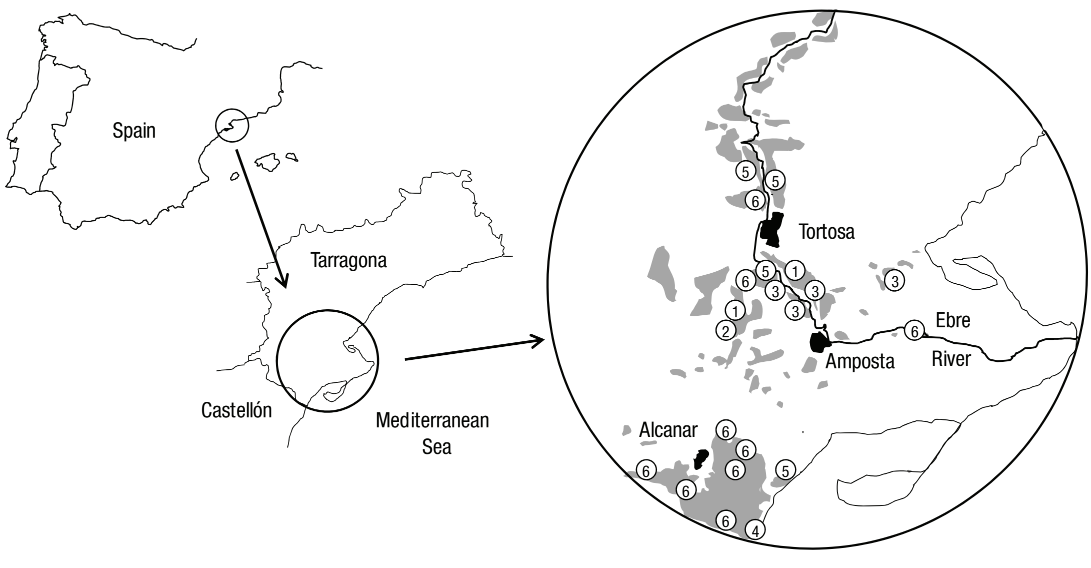

Figure 2. Citrus groves infested by *A. aurantii* in the south of Tarragona province. Grey areas represent citrus growing areas. (1) detected in 2000, (2) in 2001, (3) in 2006, (4) in 2007, (5) in 2008 and (6) in 2009.

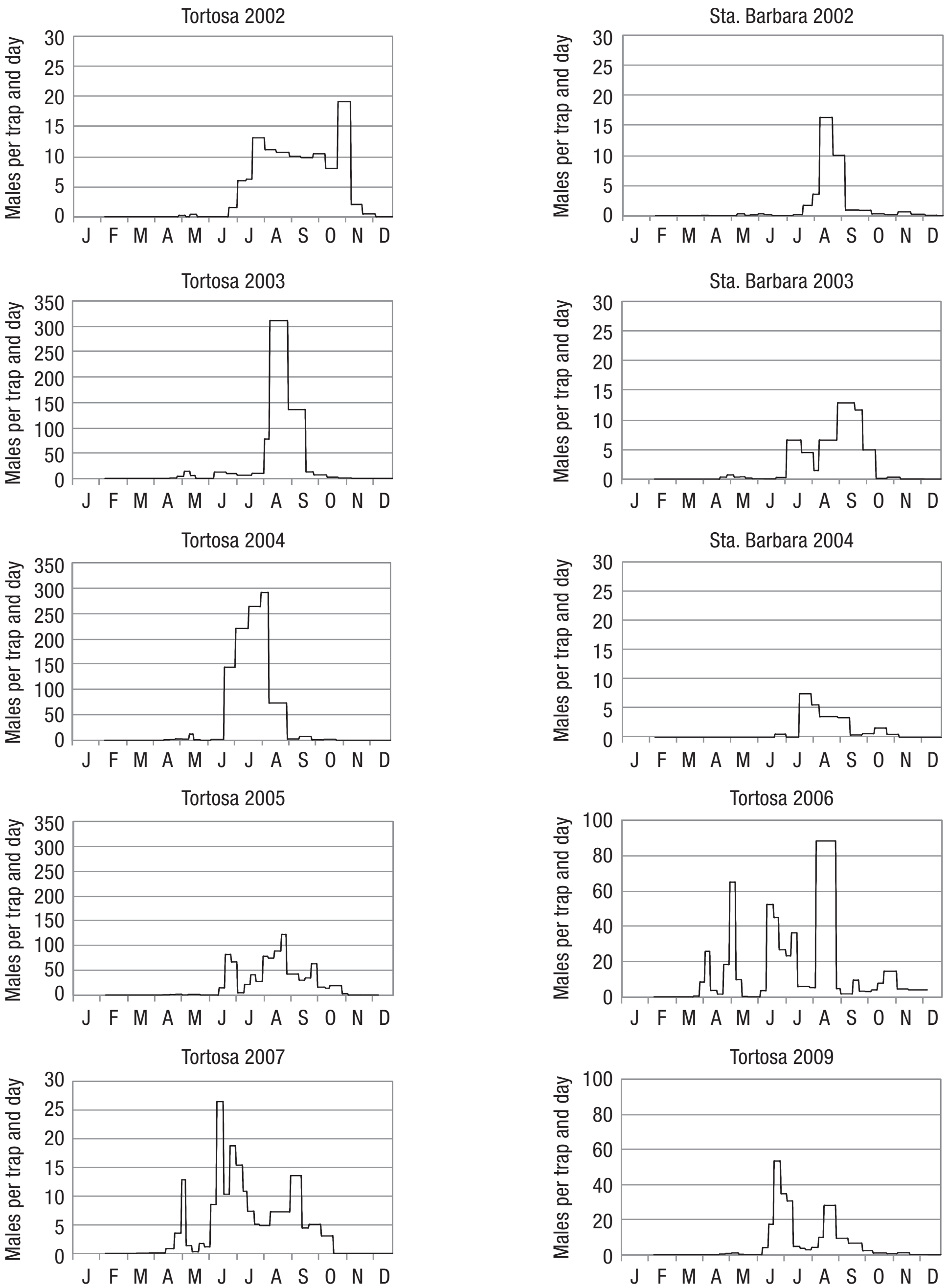

Figure 3. *Aonidiella aurantii* male flights in Tortosa (2002-2009) and Sta. Barbara (2002-2004). Number of males captured per trap and day in yellow sticky traps with pheromone.

The third flight was in August and usually exhibited the highest values ($F = 4.97$; $df = 3.35$; $p = 0.0056$); it represented over 60% of the males captured throughout the year (Table 1). The peak was reached on 20th August (± 4.40 days). Finally, the last flight occurred between the end of September and early November, with the peak occurring on 17th October (± 5.50 days).

The thermal constant estimated between male flights, using 11.7°C as the lower threshold temperature, was 611.8 ± 35.5 DD (n = 37). Since males fly to mate as they reach the adult stage, this effectively represents the heat accumulation required by *A. aurantii* to complete an entire generation.

By calculating the regression coefficient between the number of males caught per flight (Table 2), we can

Table 1. Percentage of males (mean ± standard error) of *A. aurantii* captured in lured yellow sticky traps during each flight over the total males captured (n = 36), in Tortosa (2002-2009) and Sta. Barbara (2002-2004)

Flight	Mean (± SE) percentage on each flight	Mean (± SE) number of males captured per trap and flight (n = 36)
1st	4.9 ± 2.0	156.0 ± 95.2 c
2nd	23.2 ± 6.4	1,270.6 ± 583.0 ab
3rd	63.3 ± 7.7	2,427.7 ± 905.6 a
4th	9.2 ± 3.0	483.3 ± 185.3 bc

Means with different letters within columns are significantly different (Duncan's Multiple Range Test, $p < 0.05$).

Table 2. Regression coefficient (R^2) between *A. aurantii* male abundance in different flights in two citrus groves in Tortosa (2002-2009) and Sta. Barbara (2002-2004). Number of observations analysed in parentheses

	F2	F3	F4	F1 following year
F1	0.26(10)	0.26(10)	0.28(10)	
F2		0.46(10)*	0.31(10)*	
F3			0.57(10)*	
F4				0.39(7)

F1, F2, F3 and F4: Number of *A. aurantii* males captured during the first, second, third and fourth flights, respectively. *: Model significance ($p < 0.01$).

Table 3. Number of *A. aurantii* males captured in six yellow sticky traps lured with pheromone dispensers per year and grove (Tortosa 2002-2009 and Sta. Barbara 2002-2004)

Year	Tortosa	Sta. Barbara
2002	1,462	453
2003	10,618	785
2004	13,400	323
2005	6,297	—
2006	4,970	—
2007	1,418	—
2009	1,907	—

estimate the strength of the relationship between consecutive flights. A significant positive relationship was found between the second and third flights and also between the third and fourth flights. However, no significant relationship was found between the first flight (which came from the overwintering generation) and the second, or between the last flight and the first of the following year.

The overall number of *A. aurantii* males caught in traps at the Tortosa grove increased between 2002 and 2004. After that, there was a decline from 13400 male captures in 2004 to 1907 in 2009 (Table 3). Similarly, at the Sta. Barbara grove, the number of males captured increased from 453 to 785 between 2002 and 2003, though this number later declined to 323 in 2004.There was a considerable difference in the number of males captured in the groves at Tortosa and Sta. Barbara between 2002 and 2004. The number of males captured at the Tortosa grove was between 8 and 40 times greater than at Sta. Barbara.

Seasonal trend

There were three peaks of first and second instar nymphs, which are the most sensitive to insecticides sprays. These were recorded: 1) in early June, 2) at the end of July-early August, and 3) at the end of September (Fig. 4). All of these peaks were preceded by the male flights from the previous generation from which they emerged. The first sensitive instar peak occurred on 7th June (± 1.4 days), which was approximately one month (32.7 ± 0.9 days, 282 ± 7 DD) after the first male flight, that corresponds to the overwintering generation. The second peak, which was lower than the first, was noted on 7th August (± 4.5 days), while the last peak was recorded at the end of September (29 September ± 3.0 days). During the first peak in June, the percentages of 1st and 2nd nymph instars reached 70.1 ± 2.4%, while those of the second and third instars were 57.9 ± 1.9% and 46.1 ± 4.9%, respectively.

Crawlers were first trapped on the sticky tapes at the end of April-early May, with the maximum capture being registered on 27thMay (±1.85 days): 24.8 ± 2.5 days (184.2 ± 18.1 DD) after the first male flight. The first peak of 1stand 2nd instars occurred 10.7 ± 1.6 days (79.92 ± 15.62 DD) after the peak for crawlers (Table 4).

Crawlers were captured continuously the rest of the year after the first peak on May 27th (Fig. 5). Maximum levels observed coincided with those observed during seasonal trend monitoring, in early June, early August and early October. The peaks for crawlers occurred slightly before those for the immature instar, since the latter included older instars (N1 plus N2) (Fig. 5).

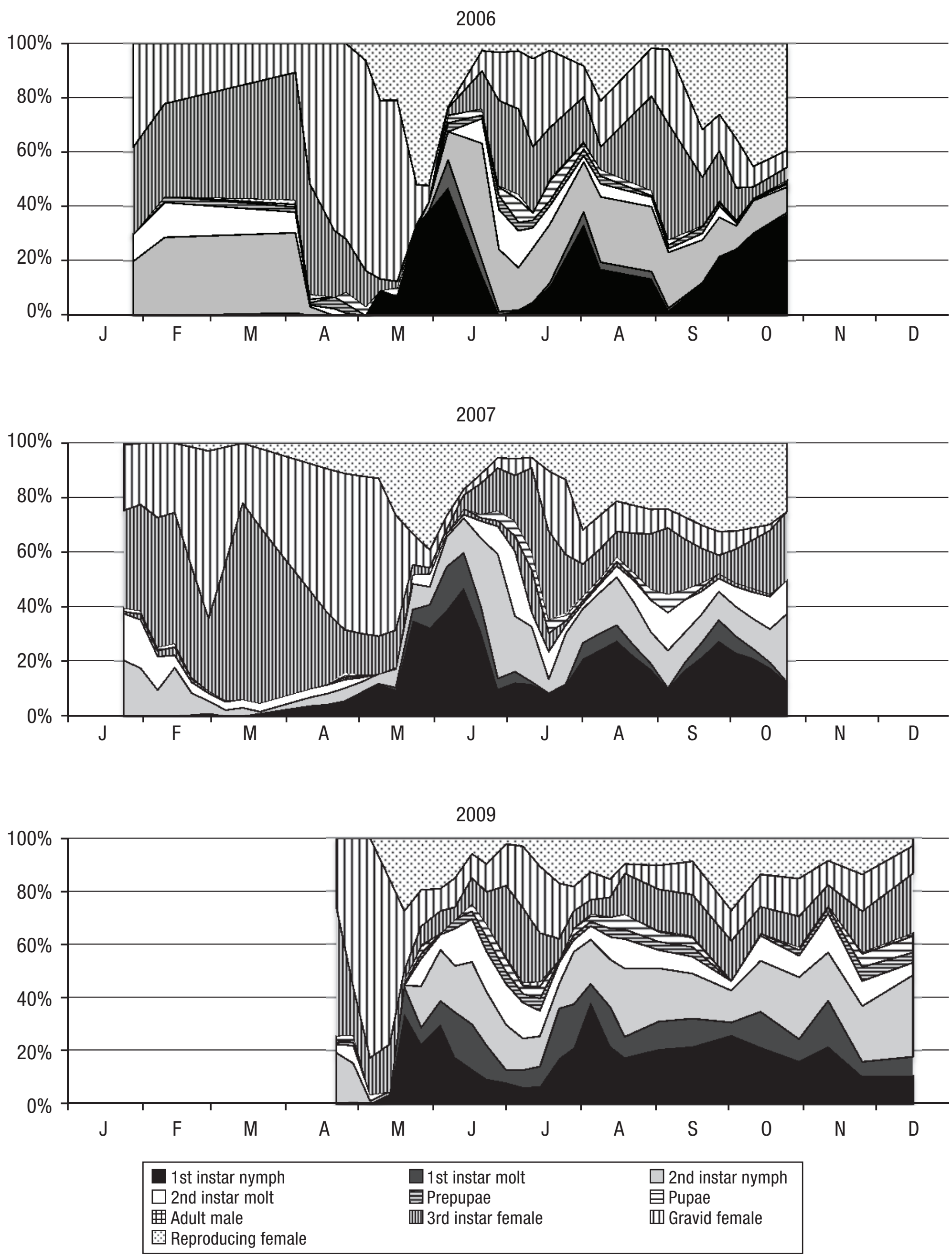

Figure 4. Seasonal trend of *A. aurantii* in Tortosa (2006, 2007 and 2009): percentage of live instars on green twigs and branches.

Table 4. Date (mean ± SE) and distance between the first male flight and the peaks of crawlers and 1st and 2nd instars

	Crawler peak	**1st and 2nd instar peak**
Date	27th May (± 1.85 days)	7th June (± 1.4 days)
Days after 1st male flight	24.8 ± 2.5 days	32.7 ± 0.9 days
Degree-days after 1st male flight	184.2 ± 18.1 DD (°C)	282 ± 7 DD (°C)

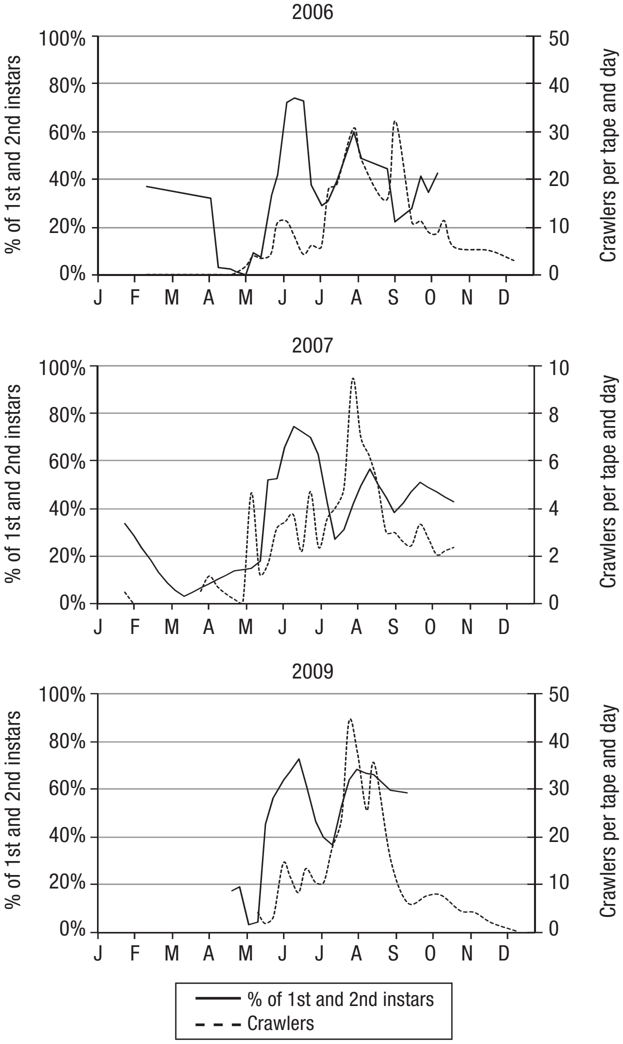

Figure 5. Percentage of 1st and 2nd instars of *A. aurantii* and number of crawlers trapped on sticky tapes in Tortosa (2006, 2007 and 2009).

Discussion

Although *A. aurantii* has been present in Catalonia since 2000, its dispersal in the area has been slow. Seven years after the first infested grove was detected, only five newly infested groves had been found. Furthermore, during the period from 2001 to 2006, no new infested groves were detected. In 2009, most of the infested groves had been already detected the previous year and most of them were located in the southern part of the area. However, most of the newest infestation points were associated with low-medium levels of *A. aurantii* infestation. From the patterns observed in the area, the dispersal does not seem to come from the initial point of infestation, but to have occurred randomly in different parts of the citrus growing area. The dispersal of armoured scale insects is slow since the only mobile instars are: adult males, which cannot start a new infestation on their own (Greathead, 1990); and first instar crawlers, which have limited mobility and are only able to spread any distance when carried by the wind (Bodenheimer, 1951). Pest dispersal can also be indirect, through the exchange of infested plant and/or packaging materials. One possible explanation for the appearance of numerous foci, particularly during the last 2-3 years, is the absence of treatments against another Diaspididae, such as the chaff scale *Parlatoria pergandii* Comstock (Hemiptera: Diaspididae), which is a key citrus pest in the region. Due to the low price of citrus products in recent years, citrus growers have tended to neglect chemical control in order to reduce their costs, particularly in small groves. This lack of pest management has indirectly contributed to increases in *A. aurantii* populations. Another possible explanation lies in the fact that *A. aurantii* can be confused with red scale *C. dictyospermi*, a pest which, in Spain, has never been present in high enough levels to require treatment. In the field, it is not possible to distinguish between these two species by the ventral cover of the gravid *A. aurantii* female and by the different structural characteristics of the female pygidium. Furthermore, some farmers did not consider *A. Aurantii* as a threat until they became aware of its presence in this area; this is similar to what is thought to have also happened in regions such as Andalucía towards the end of the 1980s (Pina, 2006).We found four male flights in citrus groves in northern Spain. The first flight, which corresponded to the overwintering generation, was the least abundant; this confirmed observations from a similar study conducted in the Valencia region (Rodrigo & Garcia-Marí, 1992). The number of males captured in each flight increased until the third flight, which corresponded to the month of August, while the capture abundance decreased considerably in the autumn flight. This was in agreement with the results obtained by Hernández-Penadés (2003) in the Valencia region, where the third flight was also the most abundant and with that flight being similar to ours in both duration and number of males. These authors reported that there were usually two more flights in September and October-November, although the August and September flights often overlap (Hernández-Penadés, 2003).We found that in our study area only the first flight of the year did not affect the abundance of the previous or following flight. These results suggest that biological or climatic factors during winter affect *A.*

aurantii populations differently. The *A. aurantii* population dynamics showed that, under our conditions, there was a relationship between two consecutive generations; this also explained the stability of *A. aurantii* populations.

The thermal constant obtained between male flights in our study was 612 DD. Kennett & Hoffman (1985), working with orange trees, found a similar thermal constant (615 DD) between the different development instars, using the same lower threshold (11.7°C). According to the species in question, Grout *et al.* (1989) obtained values of the thermal constant for *A. aurantii* that ranged from 498 to 577 in lemon and orange trees. Other authors, such as Rodrigo (1993), obtained 753 DD with 11.6°C as lower threshold, while Tumminelli *et al.*(1996) obtained 603 DD with 12°C as the lower threshold. Conti & Fisicaro (2008) also obtained similar results (609 DD) in citrus nurseries in Sicily, with the same lower threshold. By obtaining the thermal constant between male flights, we provide an additional tool that could help to predict the application of chemical sprays or the release natural enemies to control of this pest.

Temperature and humidity are the main factors that influence the number of *A. aurantii* generations per year, which can range from two to six. In California, from three to five generations appear, depending on the region (Carroll & Luck, 1984), and the same has been reported in Morocco (El-Kaoutari *et al*., 2004), Crete (Alexandrakis, 1983) and Uruguay (Asplanato, 2000). Further generations (up to six), have been detected in regions such as Israel (Sternlicht *et al.*, 1981), Queensland (Australia) (Bodenheimer, 1951) and South Africa (Bedford, 1998). In our study, three 1st and 2nd instar peaks were recorded: in early June, early August and late September. This seasonal trend of 1st and 2nd instar peaks was in agreement with other studies conducted in Spain (Ripollés, 1990; Rodrigo & Garcia-Marí, 1992). The only difference that we found related to the summer peak during early August, which was slightly advanced with respect to these other studies. According to Rodrigo & Garcia-Marí (1992), this seasonal trend is similar for leaves, twigs and fruits. As in other regions, under our conditions, when low infestation occurs, or depending on the climatic conditions, the first male flight may be almost undetectable. As a result, possible irregularities in the first male flight make it difficult to use the 1st and 2nd instar peaks of the first generation for prediction (Garcia-Marí, 2003). However, if medium to heavy infestations occur, we provide an additional tool to estimate when the first sensitive instar peak occurs. To this end, we have provided a non-destructive method, based on captures of males of the overwintering generation in lured traps.

According to our results, the seasonal trend observed in our region was also similar to that reported by Rodrigo & Garcia-Marí (1992) for other Diaspididae species in Spain. The first *A. aurantii*-sensitive instar peak in our region was more advanced than that of *P. pergandii* and *L. beckii*, respectively, occurring 7 and 15 days earlier. The highest level of sensitive instars coincided with the first peak, in early June. For this reason, as well as preventing the initial stages of fruit invasion, chemical controls are also recommended in the first generation, when the proportion of immature instars is greater (Hernández-Penadés *et al.*, 2004).Coincidence with the first peak also allow growers to control other armoured scales (chaff scale) when treating *A. aurantii*. In the area studied, the overwintering generation usually occurred as second instar females and gravid females, as also reported by Rodrigo & Garcia-Marí (1992) in the Valencia region.

In contrast to other Diaspididae, *Aonidiella aurantii* does not show a preference for the inner zones of the canopy (Rodrigo & Garcia-Marí, 1994). Crawlers show positive phototropism (Tashiro, 1966) and tend to travel to the outer canopy, settling on fruits and recent leaves. During their migration, crawlers were trapped on sticky tapes located on twigs with young females. The trend of *A. aurantii* crawlers captured was slightly advanced with respect to that of sensitive instars and served as an additional indicator for the sensitive instar peaks. Since the number of crawlers captured does not correspond to a percentage but to an absolute figure, this value increases over time as *A. aurantii* populations increase in the trees. Thus, the most suitable period to follow their trend appears to be the period preceding the first sensitive instars peak.

The number of males captured did not increase throughout the period studied. The highest capture levels were obtained in the second and third years of the study at Sta. Barbara and Tortosa, respectively. The trees in the Tortosa grove were 20-25 yr old at the beginning of the study, but *A. aurantii* seem to show a preference for young trees in a good vegetative state, which is where infestations tend to be most severe (Bodenheimer, 1951). The increase in the number of infested groves observed in the last two years suggests that *A. aurantii* will soon become a serious pest in citrus groves in Catalonia, as it already is in other citrus growing areas of Spain.

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