INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 13, No. 5, p. 200-209, 2018
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Relationship between adult's flight-eggs laying and infestation rate of date by *Ectomylois ceratoniae* in El Megaier region (Algeria)

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Article published on November 15, 2018

Key words: *Ectomyelois ceratoniae*, Adult's flight, Eggs laying, Infestation, Date.

Abstract

The date moth, *Ectomyelois ceratoniae*, infests date both in the field, on date palms and the proliferation continuing during storage. Chemical interventions have failed until today an effective protection of the date production because of the biology and feeding behavior of this pest. The larvae of this moth, feeding and developing inside the date where they are protected there. This work aims to study the relationship between fluctuations of adult's flight, the eggs laying and infestation rate on three varieties at high market value which are, Deglet Nour, Degla beida and Ghars in El Meghaier region (Algeria) during date campaigns of 2011, 2012 and 2013 years, using pheromone traps, for monitoring fluctuations of adults flight. The monitoring of laying eggs and infestation rates were performed by a sampling dates. The monitoring fluctuations of adults flight results using pheromone traps, reveals that adults are present throughout the year and they are active during a period of 9 months during which two periods of intense activity were recorded; one in spring and other in autumn which is responsible for the dates attack and other host fruits by *E. ceratoniae*. The study of the relationship between the level of the adults population, level of eggs-laying and infestation reveals that; on Deglet Nour variety, peaks of infestation and eggs-laying are recorded with or after the adult's flight peak while for two others varieties, the peaks of egg-laying and infestation are singled before or with the peak of the flight. The reasons of these variations are established.

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Introduction

In Algeria, Phytosanitary problems also penalize the phoeniculture, they have not only reduced the quantity of the production but also, they alter the quality of this one, according to Jerraya (1993), about fifty species attack the palm date tree and its products, belonging for the most part to the insect class. Some feed on sap, others consume palms and wood, and others grow at the expense of flowers and fruits that are green, ripe or in stock. Their damage in the field varies by region and variety, but three appear particularly harmful in North Africa. It's about; of *Oligonucus afrasiaticus, Parlatoria blanchardi and Ectomyelois ceratoniae*. We opt to work on *E. ceratoniae* because of the heavy damage caused by its larvae. Indeed, this pest causes up to 30% loss among date harvest in Morocco (Bouka *et al.,* 2001). In Tunisia, Dhouibi (1982), shows that the damage of *E. ceratoniae* that can go as far as the annihilation of the harvest, especially in the irrigated perimeter. The losses in California range from 10 to 40% of infested dates (Nay *et al.*, 2006). In Algeria, in Oeud Righ oasis, Wertheimer (1958), reports an infestation rate varies between 8 and 10%. Lepigre (1963), reports casualties of sorting dates greater than 10% reaching 30% in some years. At the harvest time, this percentage can sometimes get at 80% (Munier, 1973). The damage caused by the date moth is average to 22% in Ouargla region, although this rate varies from variety to another and from year to another (Idder, 1984). The objective of this study is to follow the different stages of development of *E. ceratoniae* (adult, eggs and larvae) and determined the relationship between fluctuations of adult's flight, the eggs laying and infestation rate on three varieties at high market value which are, Deglet Nour, Degla beida and Ghars in El Meghaier region (Algeria).

Materials and methods

We conducted our study in two palm groves in the region of El Meghaier (South West of El Oued, Algeria), the data that we have collected and analyzed are those of 2011, 2012 and 2013 date campaigns. The study focused at variations in abundance of adult's populations, evolution of eggs laying, infestation rate and establish the relationship between these three parameters.

Monitoring of adult's flight

The evolution of the adult population has been followed by the use of Russell IPM sexual pheromone traps. Two traps per site were placed at a rate of a trap/ha. The traps are spaced from each other by a distance of 50 m (Al-Jamali, 2006) and are attached on palm trees at a height of 1.5 m from the ground (Farazmand, 2012). A weekly check is carried out by counting the males catches. Whereas the change in pheromone capsules is carried out according to the manufacturer's indication (4 weeks in winter and 2 weeks in summer). Trapping started on 12/7/2011 until 31/12/2013 for site 01 and from 18/12/2012 until 31/12/2013 for the second site.

Monitoring of eggs lying and infestation rate

Dates sampling

To estimate the evolution of imperfect stages populations (eggs and larvae) on different varieties; Deglet Nour, Degla Beida and Ghars, we proceeded to a date sampling during the dates seasons of 2011, 2012 and 2013 for site 01 and during the date season 2013 for the second site.

The monitoring is weekly, starting on 1st June at the Bleh stage (fruit enlargement) until the harvest of dates at the Tmar stage (fruit ripening). In each site, we selected three mature and well-maintained palm of each cultivar; the cultivars have been identified with the help of the palm groves owners. A minimum of 100 dates per palm (Park and Perring, 2010) was collected weekly from four different orientations (four cardinal directions), which makes a total of more than 1800 dates/output for both sites. The samples are placed in kraft paper bags on which are indicated; the variety, the number of the palm, the date and the site of sampling. All samples are transported to the laboratory in the same day of sampling. To ensure this work, we need 24 outputs/date campaign for the variety Deglet Nour and 15 outputs/date campaign for the variety Degla Beida and Ghars, showing that Deglet Nour harvest is finished in November (variety

at late maturity) and for two other varieties, the harvest is done in mid-September (variety at early maturity).

In the laboratory, the control of dates sampled was carried out under a binocular loupe, the number of eggs laid on each variety was noted and then the fruits were dissected and examined with the naked eye, noting the number of fruits infested.

Exploitation of results

The evolution of the adult's flight was estimated by counting of male's caught number in the traps each week. The rate of eggs laying and infestation of dates on the three varieties studied are calculated; the eggs laying rate; was calculated by the percentage of dates on which is deposited at least an egg compared to the total number of dates for each sampled palm while for the infestation rate; it is the number of dates containing (a larva, excrement or nymph) of date moth compared to the total number of dates for each studied palm (Idder *et al.*, 2015). For the average of eggs laying and infestation rate for each variety in the same site, they were calculated by the sum of the eggs laying rate or infestation rate of the sampled palms compared to the total number of palms sampled (Doumandji-Mitiche, 1983).

Statistical analysis

Statistical analysis by linear regression to determine the relationship between adult's flight - egg-laying rate and the relationship between adult's flight and infestation rate was performed. Prior to the statistical analysis, the numbers of the date moth caught were transformed by the relation y '= √(y + 3/8) (Borcard, 1998 and Dagnelie, 2011), whereas the eggs laying and infestation rates undergo a normalizing transformation according to the following formula: p '= arc sin √ p, for the percentages, with p = x / 100. Normalizing transformation reduces the heteroscedasticity of the data, that is, stabilizes their variances (Sachs, 1978).

Results

Adult's flight evolution

The results of monitoring fluctuations of adult's flight are showed (Fig.1), that adults are present throughout the year and are active for a period of 9 months during which two periods of intense activity were recorded; one in spring and other in autumn. the date moth resumes its activity in spring from March to early June in 2012 with a maximum abundance of 212 males captured in April and from late of February to late of May in 2013 with peaks of 87 and 119 individuals captured in April in the first and the second site respectively.

Table 1. Regression between adult's flight and eggs laying rate on Deglet nour, Degla Beida and Ghars varieties.

Parameters				
Year	Variety	Regression droite	R^2	P
2011	Deglet Nour	Y=0,35X-6,86	0,72	<0,0001
2012		Y=0,42X-45,58	0,78	<0,0001
2013 site1		Y=1,91X-137,7	0,86	<0,0001
2013 site2		Y=1,79X-135,57	0,84	<0,0001
2011	Degla Beida	No eggs laying		
2012		Y=0,22X-15,2	0,58	0,000
2013 site1		Y=1,02X-63,53	0,95	<0,0001
2013 site2		Y=1,11X-72,33	0,95	<0,0001
2011	Ghars	No eggs laying		
2012		No eggs laying		
2013 site1		Y=0,37X-19,64	0,78	<0,0001
2013 site2		Y=0,33X-23,22	0,62	0,000

In summer, from late of May to mid-August, the flight is continuous and pursues but with more discreet catches (in 2011: 11 males, in 2012:14 males and in 2013: 37 and 23 males captured in the first and second sites respectively). In autumn the date moth restarts flight activity again, from late of August to November in 2011, a maximum abundance of 154 males is signaled in September, in 2013, for the same period, we are catcher maximum abundance of 176 and 188 males unregistered in October in the first and second sites respectively and from September to November in 2012 with peak of 156 male captured in October. In winter, the flight activity is reduced again (in December 2011: 23 males, in February 2012: 00 male and in January 2013: 1 male capture in tow sites).

Table 2. Regression between adult's flight and infestation rate on Deglet nour, Degla Beida and Ghars varieties.

		Parameters		
Year	Variety	Regression droite	R^2	P
2011	Deglet Nour	Y=2,42X+17,85	0,92	<0,0001
2012		Y=1,61X-148,09	0,89	<0,0001
2013 site1		Y=2,66X-173,27	0,92	<0,0001
2013 site2		Y=2,87X-182,31	0,97	<0,0001
2011	Degla Beida	Y=1,41X+33,86	0,98	<0,0001
2012		Y=1,07X-88,44	0,94	<0,0001
2013 site 1		Y=1,23X-58,56	0,98	<0,0001
2013 site 2		Y=2,25X-138,08	0,93	<0,0001
2011	Ghars	Y=0,64X+6,32	0,86	<0,0001
2012		Y=2,36X-201,33	0,97	<0,0001
2013 site 1		Y=0,59X-31,50	0,92	<0,0001
2013 site 2		Y=0,86X-39,39	0,72	<0,0001

Relationship between adult's flight - eggs laying and infestation rate

It should be noted that on the Deglet Nour variety (Fig. 2), eggs laying (in 2011: 5.20%, in 2012: 4.19% and in 2013: 23.22%) and infestation (in 2011: 25.68%, in 2012: 26.75% and in 2013: 40.39%) peaks are discerned after flight Peak recording during all study period. In 2013 (second site), the eggs laying peak (17.72%) is synchronized with the peak of flight, while the peak of infestation (32.31%) is recorded 15 days later (Fig. 02d). It should also be noted that during the summer period of 2011 and 2012, we recorded infestations despite the absence of laying eggs on dates.

For the Degla Beida variety in 2011 (Fig. 3a), the infestation peak (2.55%) coincides with the flight peak, but eggs laying is not detected during all monitoring period. In 2012, the infestation begins the first week of June which corresponds to the end of the first flight period. It peaks (1.49%) at the beginning of the second flight period (Fig. 3b). It is noted that there is no eggs laying during this year too. In 2013, it is observed that eggs laying rates (5.78%) are higher than the infestation rates (4.10%) in the first site (Fig. 3c). Although there is synchronization between the eggs laying peak and that of the infestation but the tow are reported before the second flight peak. In the second site and during the same year; the first infestations are detected around the first week of June. While the first eggs laying is recorded during the last week of June. In this site; the eggs laying (0.88%) and infestation peaks (4.42%) coincides with the beginning of the second flight period, in other words, the peak of infestation and eggs laying escaped from the second flight peak flight (Fig. 3d).

In 2011, on the Ghars variety, the infestation peak (3.53%) is synchronized exactly with the peak of the second flight period, the eggs laying is not detected

this year (Fig. 4a). In 2012, with the first flight period lasting until the first week of June, the first infestations are also recorded during this week, with a very important rate (2.84%) then that recorded at the beginning of the second flight period. It should be signalizing that no eggs laying is recorded during the companion season on this variety too (Fig. 4b).

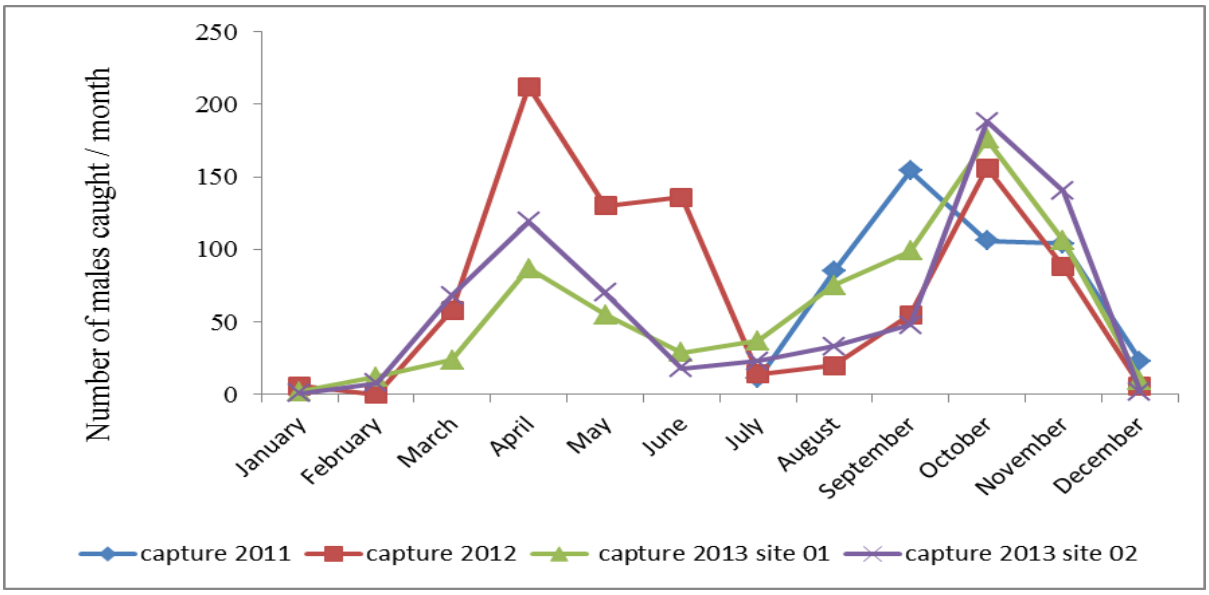

Fig. 1. Evolution of *E. ceratoniae* adult's flight during the year.

In 2013 and in the first site, as well as the Degla Beida variety, it is observed that the eggs laying rate (1.80%) on the Ghars variety is greater than the infestation rate (1.42%). Knowing that the first eggs laying are detected in July, the first infestations are reported from the beginning of June which corresponds to the end of the first flight period. On the Ghars variety, there is synchronization between the eggs laying peak and that of the infestation. Both peaks are detected before the peak flight of the second period (Fig. 04c). In the second site, during 2013, neither eggs laying peak nor peak infestation are recorded at the beginning of the second flight period (Fig. 4d).

Statistical analysis by linear regression between adult's flight and eggs laying rate (Table 1), shows that the level of the imaginal population and eggs laying rate on Deglet Nour variety are significantly and positively correlated with R^2 varied between 0.72 and 0,86 and $p < 0.0001$ signaled during all period of study. In 2012, a significant and positive correlation was recorded between flight and egg laying rate on Degla Beida variety with $R^2 = 0.58$ and $p = 0.000$.

Likewise in 2013 there was a significant and positive correlation with $R^2 = 0.95$ and $p < 0.0001$ in the both sites.

From the same table, we note that there is a significant and positive correlation between flight and egg laying rate on Ghars varity with $R^2 = 0.78$, $p < 0.0001$ and $R^2 = 0.62$, $p = 0.000$ in the first and second site respectively.

Similarly, regression between adult's flight and infestation rate (Table 2) shows that during all period of study, there is a significant and positive correlation between the level of the imaginal population and the infestation rate on the three varieties with R^2 varied between 0,72 and 0,98 $p < 0.0001$.

Discussion

Sexual trapping of harmful phycitinae moths in products stored appears to be a method of monitoring the activity of this insect inexpensive and able to provide valuable biological information to decide appropriate moment of insecticide application (Fleurat-Lessard, 1986).

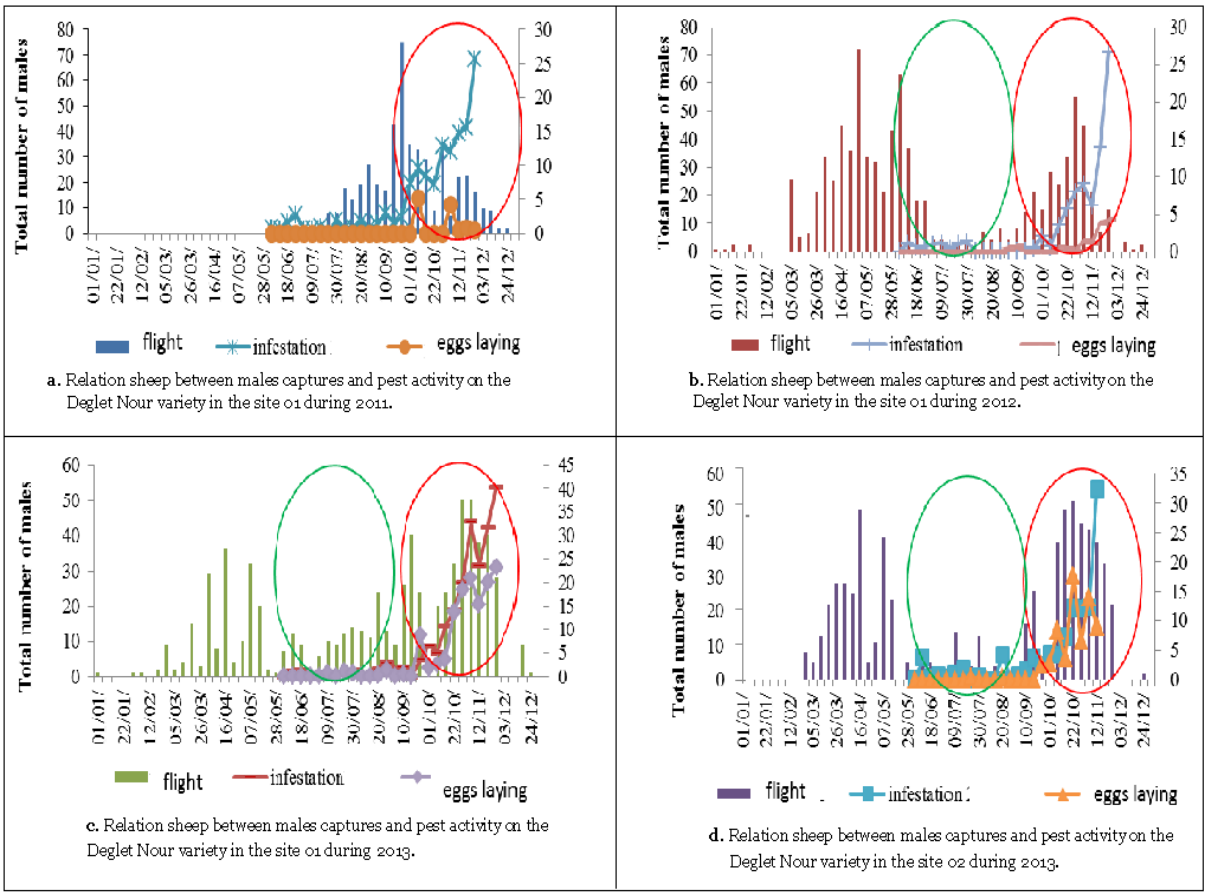

Fig. 2 (a, b, c and d). Relation sheep between males captures and pest activity on the Deglet Nour variety.

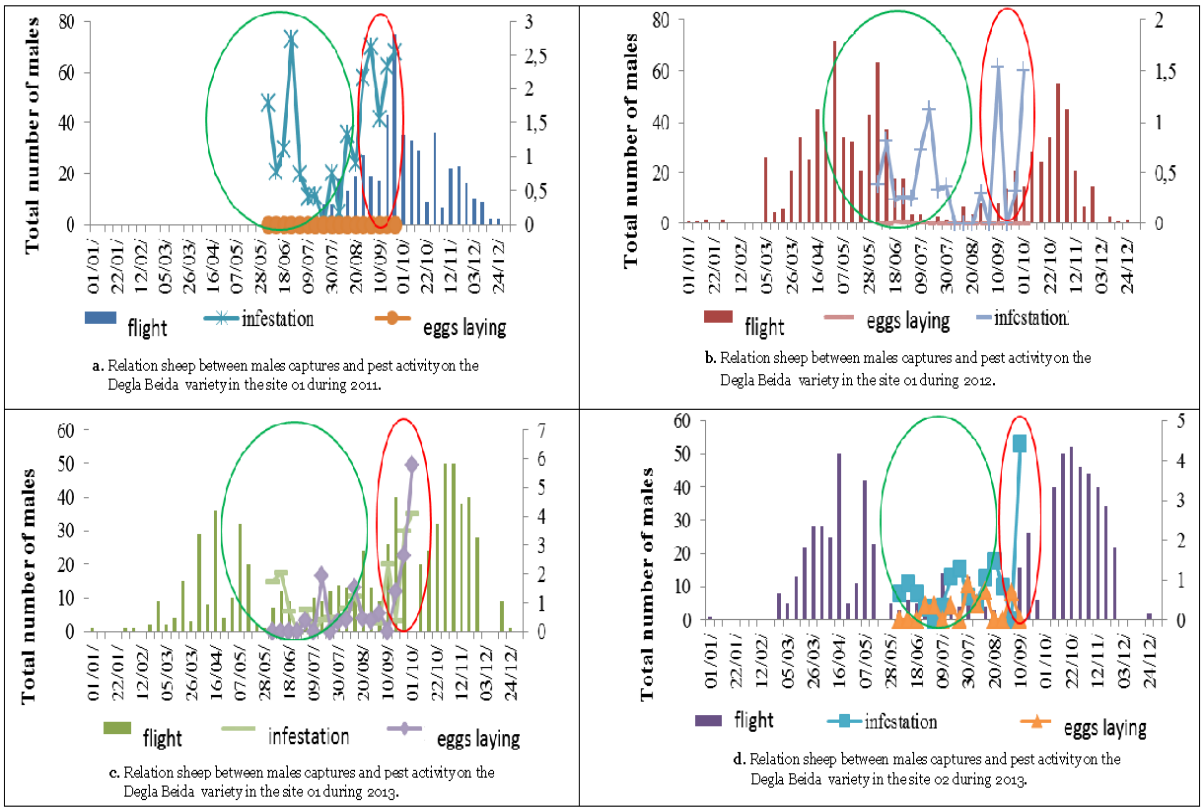

Fig. 3 (a, b, c and d). Relation sheep between males captures and pest activity on the Degla Beida variety.

The most important parameters to study by this technique are the beginning and the peak of flight. Our results which recorded the presence of two periods of intense activity; one in spring and other in autumn are similar to the results of Mehaoua *et al.* (2015), which show that the date moth has a permanent flight throughout the year with two flight periods in the region of Tolga (Algeria), the first flight starts in March until the end of June. The second begins from August to November. Dhouibi (1982), note the succession of four overlapping generations on pomegranate, and two only on palm tree in Tunisia.

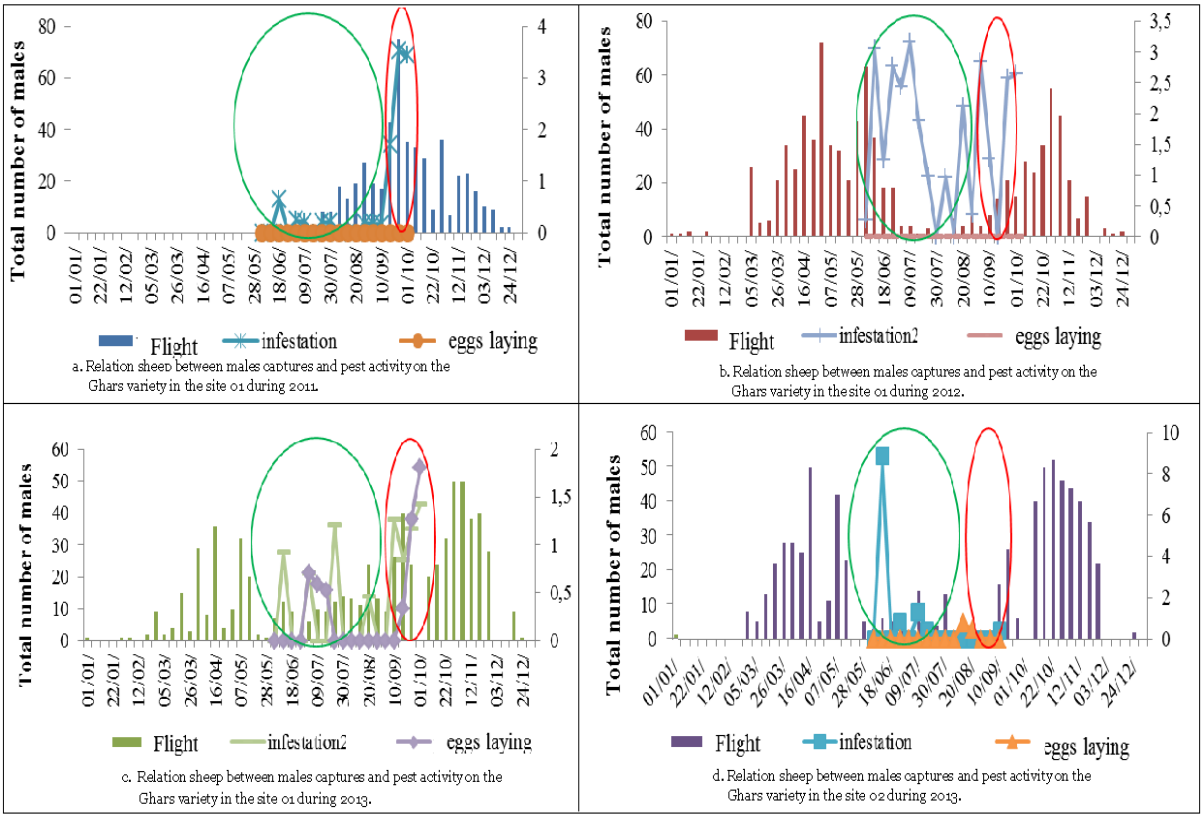

Fig. 4 (a, b, c and d). Relation sheep between males captures and pest activity on the Ghars variety.

The insect is present from February until the end of December, with a massive flight in April of adults coming from wintering caterpillars (which probably attack pomegranates existing in the palm groves) and it is only in late August early September, when we observe attacks on barely mature dates. Yildirim and Baspinar (2015), prove that adults of *E. ceratoniae* are present in pomegranate orchards in the Aegean region (western of Turkey), between May and November with a single peak recorded in August. While Ozturk and Ulusoy (2011), note in the pomegranate orchards of the Adana, Mersin and Osmaniye plains (Turkey) that the date moth is active in about 6 to 7 months from April to November in both years of experiment (2008 and 2009). However, it was determined that population levels of *E. ceratoniae* in the areas mentioned above, never reach the density being able to give damage on pomegranate. According to Doumaindji (1981), the number of generations varies from 1 to 4 depending on climatic conditions and host plants.

Monitoring of egg laying and infestation rate evolution in terms of adult abundance reveals a strong correlation between catches of *E. ceratoniae* males - eggs laying (in the case where we recorded an eggs laying) and infestation rate in the phoenicultural orchard. However, Besson and Joly (1978 in Stockel, 1984), indicate a total absence of correspondence between catches of *Lobesia botrana* males and the average number of caterpillars per cluster, worse, these same authors note that this number can vary

from simple to double for the same catch sexual trap in adjacent parcel. Likewise Rochefort *et al.,* (2003), note that the presence of sod webworms adult in light traps does not seem to be a good indicator of a severe infestation of lawn by larvae of this species. Despite the abundance of the date moth adult population in spring; the egg laying and infestation rate are invaluable because of the earliness of the first flight period relative to evolution of dates stages. At this time, in the Tunisian oases, the date moth find only the pomegranates as relay plant which allows them to develop their first generations until the dates reach maturity (Dhouibi, 1982). While Wertheimer (1958), proves that in the Algerian oases, the first contaminations on date of the pending harvest are discovered from the end of August and only on the first fruits arriving at the beginning of the maturity stage, those born before this date, lay their eggs in any places of the palm grove or buildings. In summer, following to relatively discreet flight, the rate of egg laying and infestation are relatively feeble. Maille and Carraretto (2011), note that the low damage rate of *Lobbesia botrana*, which did not exceed 5%, is probably related to the weather conditions in June (high temperatures and low humidity) that have may been favorable for egg mortality. In autumn, following to flight peak in October, there is an egg laying peak followed by infestation peak in November. Bensalah (2015) indicates the appearance of the third generation between October and November synchronized with date's maturity and it is this generation which is responsible for damage to the quality of dates.

Conclusion

We concluded that in the study region there are two main flight periods, the first in spring. The recovery of *E. ceratonaie* imagos in the spring, coincides with the attenuation of winter temperatures, the pollination of the date palm (March to April), the fruiting of the pomegranate and the fig tree (moth host plant).The second in autumn, during which, several factors can explain the recovery of adult flight of this pest. It should be noted that at the beginning of the second flight period Degla Beida and Ghars varieties are maturing. In the medal and last of this period, the Deglet Nour variety is maturing too. During this period, the summer temperatures are refreshed between September and October until mid-November. In summer and winter, the number of males caught is very low throughout the all period of study. The study of the relationship between the level of the adults population and level of eggs-laying and infestation reveals that; at Deglet Nour, peaks of infestation and eggs-laying are recorded with or after the peak of the flight while for two others varieties, the peaks of egg-laying and infestation are singled before or with the peak of the flight. The activity of the date moth is not only influenced by climatic conditions and the host plant but also by the variety and the phenological stages of host plants

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