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Behavioral Effect of The Specific Sex Pheromone PH-227-1RR Towards Butterflies Codling Moth *Cydia pomonella* in Two Apple Orchards in Draa Ben Khedda Region of North Algeria

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Abstract:
The study focused on behavioral effect of the specific sex pheromone PH-227-1RR towards butterflies' codling moth *Cydia pomonella* L. in apple orchards on 2 different varieties (Anna and Dorset golden) in Draa Ben Khedda region of North Algeria. The results show the existence of two flight periods (2 generations) on the Anna and Dorset golden varieties, overlapping during months from March to July. Flights stopped around early July noted in study area, it appreciably coincides with the harvest of the fruits and with the diapause period of the caterpillars of the last flight. So the appearance of the first generation occurs on variable dates according to the rupture of the diapause and the duration of development of the pupae which depend on climatic conditions.

Keywords: Behavioral, Sex Pheromone, *Cydia pomonella*, Apple Orchards.

INTRODUCTION

The codling moth *Cydia pomonella* is considered a pest in apple orchards (Schweizer, 2006). In the absence of phytosanitary treatment, it can cause total destruction of crops (Fraval, 2002). Chemical control is generally used to suppress this micro-lepidopteran causing considerable damage inside the apples, nevertheless, in recent years there have been phenomena of resistance to pesticides (Sauphanor and *al*., 2009). As part of a study on the spatio-temporal relationships between the codling moth *C.pomonella* and its host plant, it seems necessary to us to study the cycle of the species. Through this study, we will be able to identify the bioecological characteristics of the pest linked to the specific conditions of our agro-systems and the factors likely to favor its dynamics. The objective of this study is to determine the behavior of codling moths *C.pomonella* regarding of the specific sex pheromone PH-227-1RR in two apple orchards in Draa Ben Khedda region of North Algeria.

MATERIALS AND METHODS

For the study of the bioecology of the codling moth *C.pomonella*, a follow-up is carried out on the flight of adult males by specific sexual pheromone traps.

Plant material

The plant material consists of two varieties located in two different plots in the Draa Ben Khedda region, namely: Anna and Dorset golden.

Capture of adult male C. pomonella by sex pheromone trap

Attractive sex pheromone traps, from the regional plant protection station of the province of Tizi-Ouzou, are used to track the progress of adult male flights as well as the estimate of the level of populations of the pest *C.pomonella* at two study plots. The sex trap consists of a plate coated with glue on which is deposited a capsule containing the specific pheromone PH-227-1RR attracting males who sneak into the delta trap and get trapped in the sticky surface (Fig.1).

The device is attached by a wire to the foliage tree, deposited at man's height. The installation of the trap is carried out 15 days after setting to determine the date of appearance of the first flight. They are renewed every 3 weeks.

Figure 1: Sexual pheromone delta trap designed to capture males of the codling moth (Guermah, 2019).

Observations are carried out once a week for 6 months (from the beginning of February until the end of July), covering the flowering and fruiting period of Malus pumila during the year 2016. For each trip, the date of the catches and the total number of butterflies caught at each study plot are mentioned. According to Coutin (1960), Balachowsky (1966) and Audemard (1976), the codling moth of apples and pears belongs to:

Regne	**Animalia**
Embranchement	Arthropoda
Classe	Insecta
Sous Classe	Pterygota
Ordre	Lepidoptera
Famille	Tortricidae
Sous Famille	Olethreutinae
Genre	*Cydia*
Espece	*Cydia pomonellla* L. (1785)

Life cycle

According to Chouinard and *al*. (2000), the codling moth overwinters as a caterpillar in a cocoon of silk inserted into the cracks in the bark of apple trees, or in the ground at the foot of the trees, it turns into a chrysalis when spring arrives ; the emergence of the adult takes place at the end of May (time corresponding to the flowering of apple trees), eggs laid on foliage or fruit, hatch after 5 to 15 days (depending on temperature) and the larvae penetrate deeply into the ripening apples (Fig. 2).

The larvae or caterpillars of the pest feed on the flesh of the fruit by going towards the heart to be able to consume the seeds, the 5th tier caterpillar then leaves the fruit and heads towards the ground, either by descending on the bark of the trees, or by being slipped at the end of a silk thread or, coming out of the fruit when it falls to the ground (Hmimina, 2007).

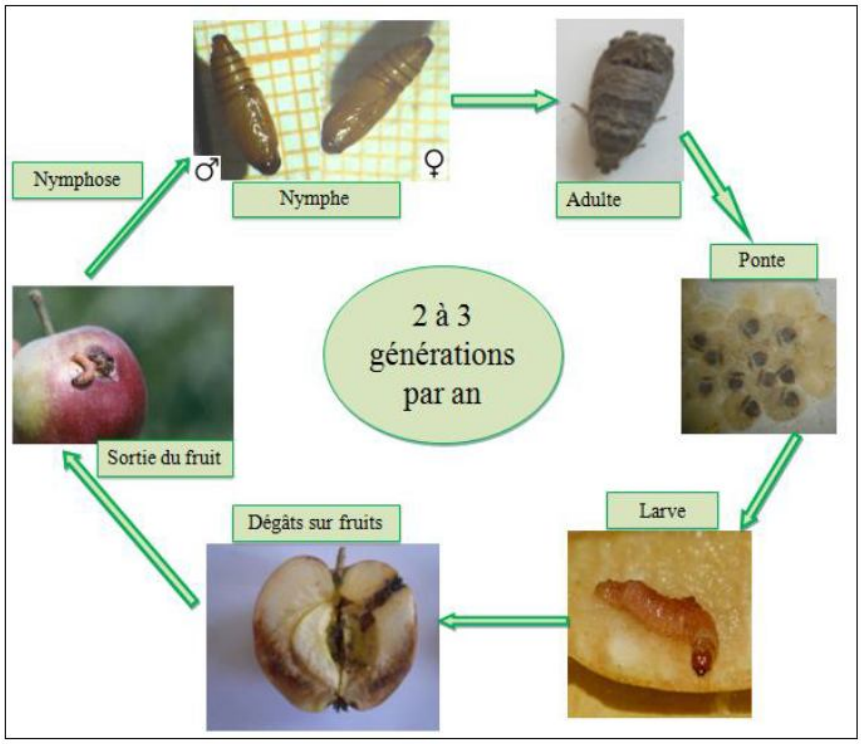

Figure 2: life cycle of *C.pomonella* (Guermah, 2019).

Location of the Draa Ben Khedda region

The study took place in Draa Ben Khedda in the wilaya of Tizi-Ouzou which is located in the North of Algeria, bounded to the north by the Mediterranean Sea, to the south by the wilaya of Bouira, to the east by the wilaya of Bejaia and to the west by the wilaya of Boumerdès (Fig. 3).

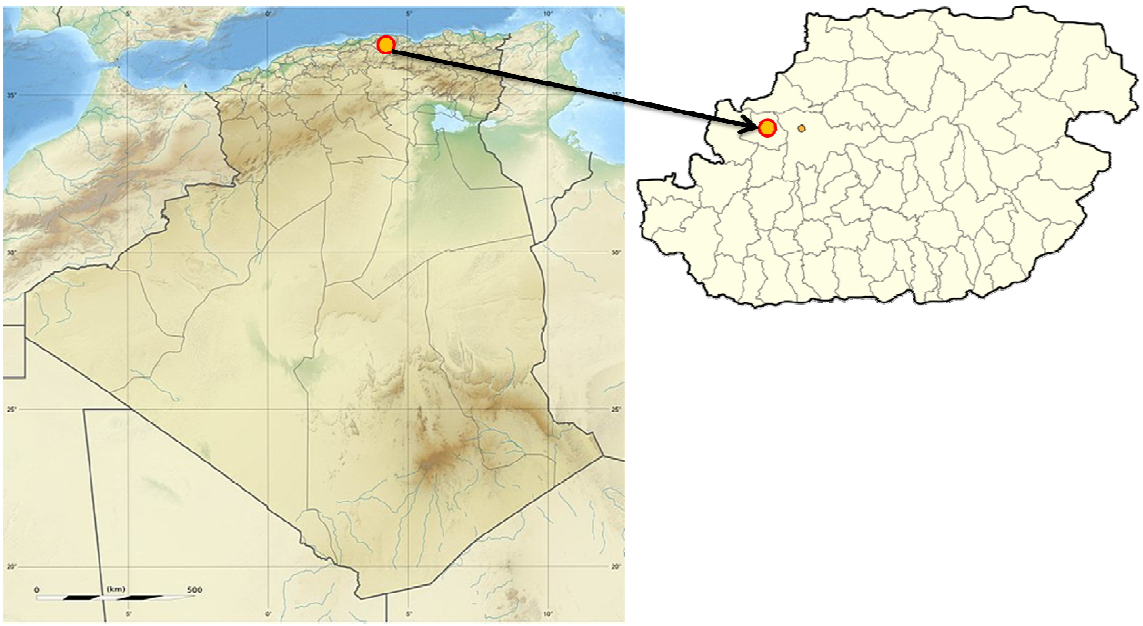

Figure 3: location of the study area in Draa Ben Khedda region of North Algeria (Google maps, 2016)

Presentation of Draa Ben Khedda orchard

The study orchard is located north of the city of Draa Ben Khedda; it is bordered to the north by an apple orchard, to the south by a cemetery, to the east by the regional plant protection station (SRPV) and to the west by a vineyard. With an area of 5.5 ha, it has around 11,800 trees; 11600 a vineyard and 2200 apple tree of which there are two varieties, Anna and Dorset golden. The orchard is surrounded by north and west breezes. The planting distance is 1,5m×2m and trees led in irregular shape. The total number in the plot is 2200 trees of which 1200 trees of the Anna variety or 54.5% and 1000 trees of the Dorset golden variety or 45.5%.

Climate summary

The climatic synthesis of a given region can be done by the analysis of the pluviothermal diagram of Bagnouls and Gaussen (1953) and by the climagram of Emberger (1955).

According to Estienne and Godard (1970), the Mediterranean climate is a climate of transition between the temperate zone and the tropical zone; it is characterized by a dry season corresponding to summer and a cold wet season which corresponds to winter.

Pluviothermal diagram of Bagnouls and Gaussen

Bagnouls and Gaussen (1953) consider as dry month any month where the precipitation is less than or equal to twice the temperature **(p≤2T)**

The graph is made by plotting the months on the abscissa and the ordinates, on the right the precipitation, and on the left the temperatures, on a scale twice that of precipitation. The period that extends between the two curves corresponds to the duration of the dry period (Fig. 4). For this study the dry period lasts 4 months (from the beginning of June to the end of September). The wet period lasts for 8 months (from October until the end of May).

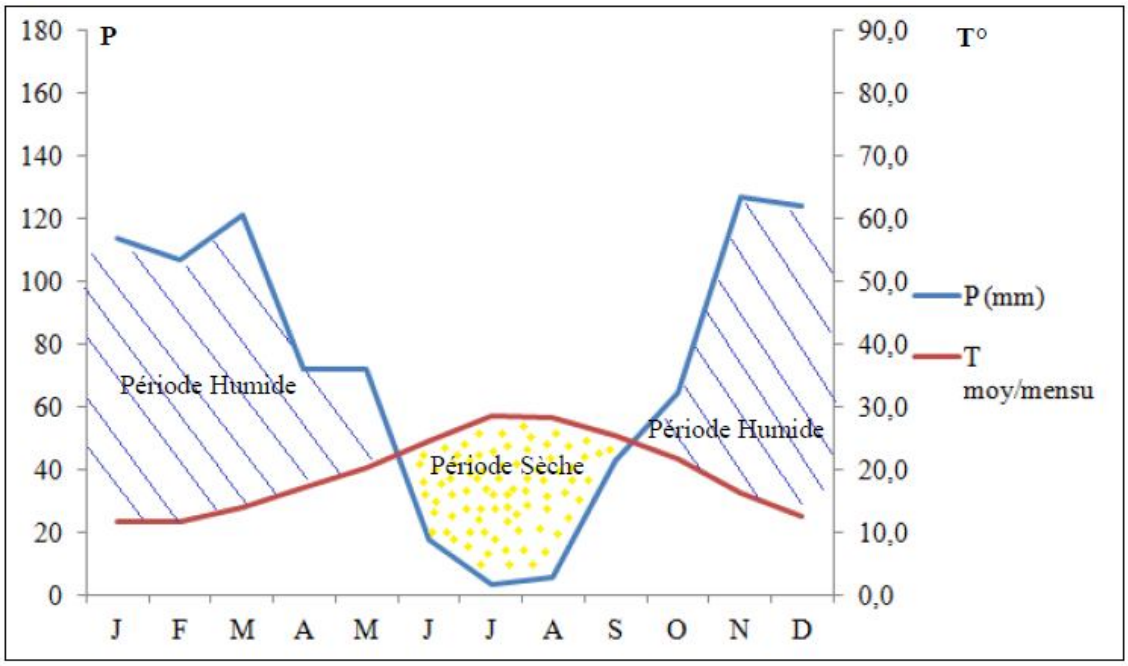

Figure 4: Pluviothermal diagram of Bagnouls and Gaussen of the Tizi-Ouzou region over 10 years covering the study period (2006 - 2016).

RESULTS

Temporal evolution of the number of adults of *C. pomonella* captured in study plots

Flight curves of codling moth adults *C.pomonella* are the result of males caught using sex traps using a specific pheromone diffuser PH-227-1RR at two study plots in 2016.

At the Anna variety plot, the first flight extends from the end of March fruit set until the end of April, the second begins in mid-May fruiting period and ends in late June see early July fruit ripening and harvesting period (Fig. 5).

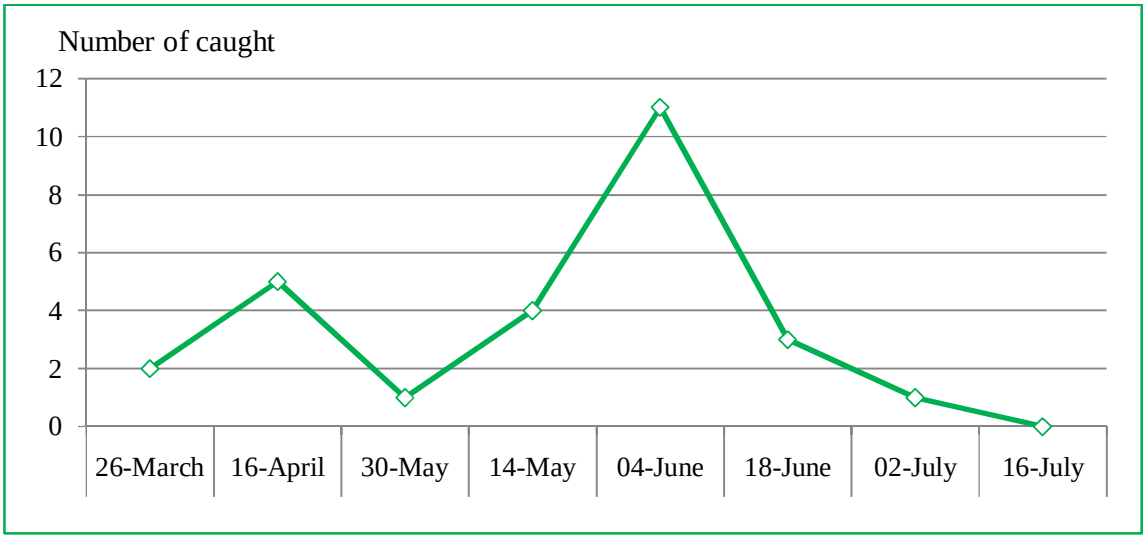

Figure 5: Flight curve of codling moth adults in the Draa Ben Khedda region: Anna variety.

At the level of the Dorset golden variety plot, the first flight extends from the end of April fruiting period until the end of May fruiting period, the second flight extends from the beginning of June fruiting period and ends towards the end of June see early July the second flight extends from the beginning of June fruiting period and ends towards the end of June see early July (Fig. 6).

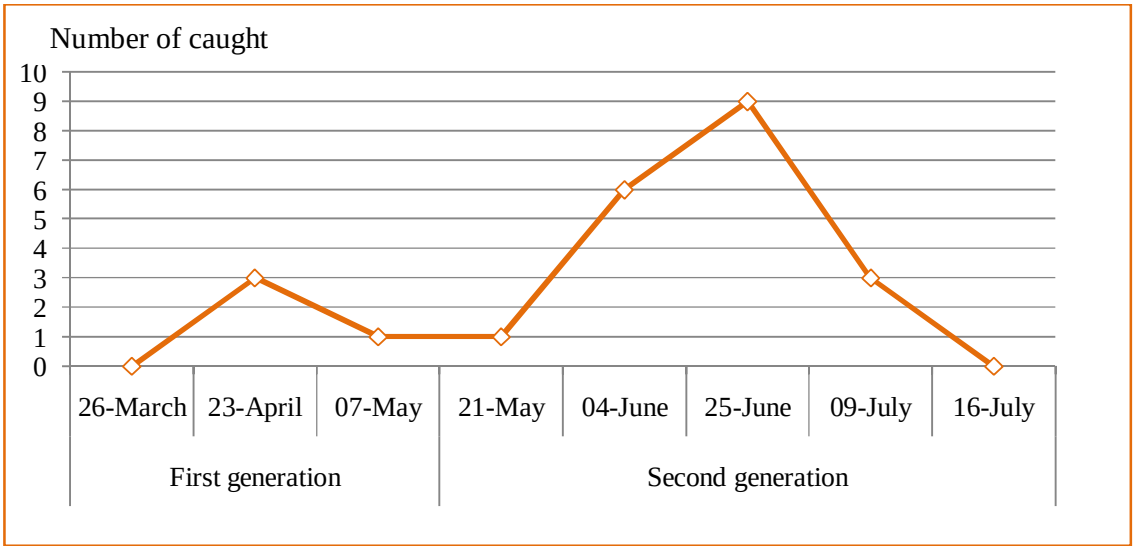

Figure 6: Flight curve of codling moth adults in the Draa Ben Khedda region: variety Dorset golden.

At the Anna variety plot, 2 peaks are recorded, the first is noted on April 16, the largest peak is observed on June 04 with 11 male butterflies captured.

At the level of the Dorset golden variety plot, 2 peaks are recorded, the first is noted on May 07, the largest peak is observed on June 24 with 9 male butterflies captured.

The periods of activity of the *Cydia pomonella* codling moth reveal the existence of two flight periods corresponding to two generations per year in the region of Draa Ben Khedda located in northern Algeria.

The flights stopped around mid-July were noticed on the two varieties of apple studied, it generally coincides with the harvest of the fruits and with the diapause period of the caterpillars of the last flight. So the appearance of the first generation occurs on variable dates depending on the break in diapause and the duration of development of pupae which depend on climatic conditions.

According to Wildbolz (1958), Coutin (1960) and Jackson (1979), codling moths lay their eggs on the leaves near the fruit in connection with the specific smell emitted by apples and physical stimuli (trichomes); egg-laying would therefore be closely linked to the presence of apples on the tree, apples that give off odors that attract carpocapses and stimulate their laying near these fruits.

DISCUSSION AND CONCLUSION

Flight curves of codling moth adults *C. pomonella* s result in the capture of males using sex traps using a specific pheromone diffuser PH-227-1RR in two study plots in 2016. According to Audemard (1979), the level of codling moth catches in pheromone traps varies depending on many factors which relate to the population (trapping conditions, characteristics of the agro-ecosystem and climatic conditions as well as the varietal characteristics of host plants).

The use of sex pheromone traps allows giving good indications on the moment of appearance of butterflies and the importance of the pest populations, which can help predict the risk of attack in the context of reasoned chemical control in apple orchards.

At the Anna variety plot, the first flight extends from the end of March fruit set until the end of April, the second begins in mid-May fruiting period and ends in late June see early July fruit ripening and harvesting period.

At the level of the Dorset golden variety plot, the first flight extends from the end of April fruiting period until the end of May fruiting period, the second flight extends from the beginning of June fruiting period and ends towards the end of June see early July ripening and fruit harvesting period.

In the study area, the codling moth *C. pomonella* is bivoltin that is to say that this pest has two generations per year. According to Hmimina (2007), the number of generations changes depending on the altitude; it decreases when it increases, this may be related to the temperature which, according to Seltzer (1946) the minimum and maximum temperature decrease by 0.4°C and 0.7°C respectively for every 100 meters of altitude.

The results obtained confirm the flight periods of adult male codling moth over apple trees taking into account the environmental factor, climatic and varietal, which indicates the presence of two generations per year in Draa Ben Khedda orchard.

In the same study plots, Guermah (2019) tested the effect of the pheromone (E,E)- 8,10-Dodecadien-1-ol on the attractiveness of males of the codling moth during the years 2014 and 2015. We note that the results are almost similar at the level of the development cycle of the codling moth which presents two generations per year. However, the effect of the pheromone PH-227-1RR turns out to be more attractive than the pheromone (E,E)- 8,10-Dodecadien-1-ol towards male adults *Cydia pomonella*.

Our results corroborate those Belkadi and Hamli (1998), those available in the SRPV of Aïn-touta and Chafaa (2008), who revealed the existence of three generations a year, with flying activity spread between the beginning of April and the end of September see early October. In Tunisia, Gabtini (1995) reports 3 to 4 generations per year.

In France, Ramade (1984) and Toubon (2008) found that there is an evolution of codling moth populations and an orientation towards a viable third generation in the South and a second generation in the North. Otherwise, Mansour and Mohamed (2000) used sex traps in Syria as a means of combating *C.pomonella* which reduced the number of interventions from 6 to 2 for pesticides.

Soltani and *al*. (1986) report that the flight activity of this pest is recorded at the beginning of April, this is the case in Boufarik and Aïn-touta where the adults appear almost at the same period, however, a one to two week lag in appearance of adults was recorded in 2014 and 2015 in the Tizi-Ouzou region.

Chafaa (2008) reports that the number of generations remains the same (three generations) with the climate change of the year after doing a follow-up of four successive years in Aïn-touta.

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