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Bioecology of Codling Moth *Cydia pomonella* (Lepidoptera: Tortricidae) and Study of the Associated Entomofauna on Anna Variety in Tadmaitregion (Tizi-Ouzou, Algeria)

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Abstract:

*Cydia pomonella*is a Lepidoptera of family Tortricidae, Polyvoltin dependent on its host plant apple tree *Malus domestica*. This insect presents two to three generations per year depending on the climatic conditions of the environment, the characteristics of the agro-ecosystem as well as the varietal characteristics of the host plants. This study aims to evaluate the population dynamics of codling moth *C. pomonella* by using specific sex pheromone traps and the existence of possible predators of this insect by the realization of entomo fauna inventory to highlight an appropriate control strategy within a parcel of apple tree of Anna variety in Tadmait region of Tizi-Ouzou. The results reveal the existence of 3 flight periods, which indicates 3 main generations per year. Insect inventory realized by using three sampling methods: the sweep net, Barber traps and colored traps allowed us to capture 42 species divided into 29 families, belonging to 7 orders. The centesimal frequency values applied to the listed insect species vary from one type of trapping to another; each sampling method is relative to a representative order group. Insect diets are extremely diverse, because of the structures and functioning of the mouthparts, of the structural and functional division of the digestive tract. We were able to distinguish six large sets from the 42 insect species selected.

Keywords: *Cydia pomonella*, entomofauna, Anna, Apple tree, Tadmait.

1. INTRODUCTION

The codling moth *Cydia pomonella* is considered a key bio-aggressor in apple orchards (Schweizer, 2006). In the absence of phytosanitary treatment, it can cause the total destruction of the crops (Fraval, 2002).

Chemical control is generally used to repress this micro-lepidopteran causing considerable damage inside apples; nevertheless, it appears the last years of pesticide resistance phenomena (Sauphanor et *al*., 2009).

As part of a study on spatio-temporal relationships between *C. pomonella* codling moth and its host plant, it seems necessary to study the species cycle and we deemed essential, In this study, to make an inventory of the entomofauna associated with apple growing in Tizi-Ouzou region (Kabylie), in order to improve our knowledge about insect biodiversity and their classification according to the different trophic regimes.

2. MATERIALS AND METHODS

For the study of the bioecology of codling moth *C. pomonella*, a follow-up is done on the flight of the adult males by sexual pheromone traps at the rate of one outing per week during the activity of codling moth for the year 2015.

Regarding the study of entomo fauna, we opted for the use of three methods of capture, namely the sweep net; Barber traps and colored traps, on a one outing per week during 2015.

2.1. Capture of adult *C. pomonella* by sex pheromone trap

Attractive sexual pheromone traps are used for tracking the flight of male adults, as well as the estimate of the population level of the pest *C. pomonella* in the study plot. The sexual trap consists of a plate coated with glue on which is deposited a capsule containing the specific pheromone (E, E)-8,10-Dodecadien-1-ol attracting males who break into the delta trap and get trapped in the stuck surface(Fig. 1). The device is fixed by a wire to the tree's foliage, deposited at the height of man. The trap is installed 15 days after setting to determine the date of appearance of the first flight.

Figure 1: Pheromone Sexual Delta trap to capture males from apple moth (Original, 2015).

Observations are made once a week for 5 months (from mid-April until the end of August), covering the period of flowering and fruiting of *Malus pumila* and this during the year of study 2015. For each output, the date of catch and the total number of captured butterflies.

2.2. Sweep net

The sweep net is applied in the herbaceous layer between the rows of the field of study once a week during the study period, by dislodging insects hidden in the vegetation.

2.3. Barber traps

Nine Barber traps are deposited in the study plot arranged in quadra, filled to 2/3 of their contents with soapy water; for collecting walking insects; they are visited once a week. The content was collected and placed in pots with labels on which is indicated the release date and the trap concerned.

2.4. Colored traps

Nine colored traps are suspended by a wire to the apple trees and filled with soapy water at two-thirds of their height; to collect arthropods housed in the foliage. All samples collected in the field are reported to the laboratory for sorting and identified under a binocular loupe. The determination of insect species is based on morphological characters as well as their chaetotaxy using different identification keys (Seguy, 1923; Perrier, 1961; Chinery, 1988et Piham, 1986).

2.5. Exploitation of results

For the treatment of the results obtained, different ecological indices are applied. Total wealth is calculated for each sampling method. This is the total number of species that includes the settlement considered in an ecosystem (Ramade, 2003).Relative abundance (centesimal frequency) Fc (%) is also rated; it tells us about the percentage of individuals of a species Ni on the total number of individuals N (Dajoz, 1971).

Fc= Ni x 100/ N

Ni: number of individuals of the species considered.

According to (Barbault, 1981), species diversity is calculated by different indices; the most used is Shannon-Weaver. It is calculated by the following formula:

H'= - ∑ qi log2 qi

H': The diversity index expressed in bit units.

qi :The probability of meeting the speciesi.

ni :Number of individuals of the speciesi.

N: Total number of all species combined.

Equitability is the ratio of observed diversity (H') at the maximum theoretical diversity (H' max) (Barbault, 1981).H' maxis calculated by the following formula:

H' max= Log 2 S

S: Is the total number of species found during N readings.

H': max is expressed in bits

E= H'/H max

3. RESULTS

Adult flight curves of codling moth *C. pomonella* are the result of catches of males by the use of sexual trapsu sing a specific pheromone diffuser (E,E)-8,10-Dodecadien-1-ol. The periods of activity of codling moth, reveal the existence of three periods of flight during five months, from April to August in the study plot. The first flight runs from mid-April corresponding to the fruiting period of apple fruit until the end of May fruiting period, the second flight starts from June until the end of July fruit ripening period and the third flight occurs from late July to late August (Fig. 2).

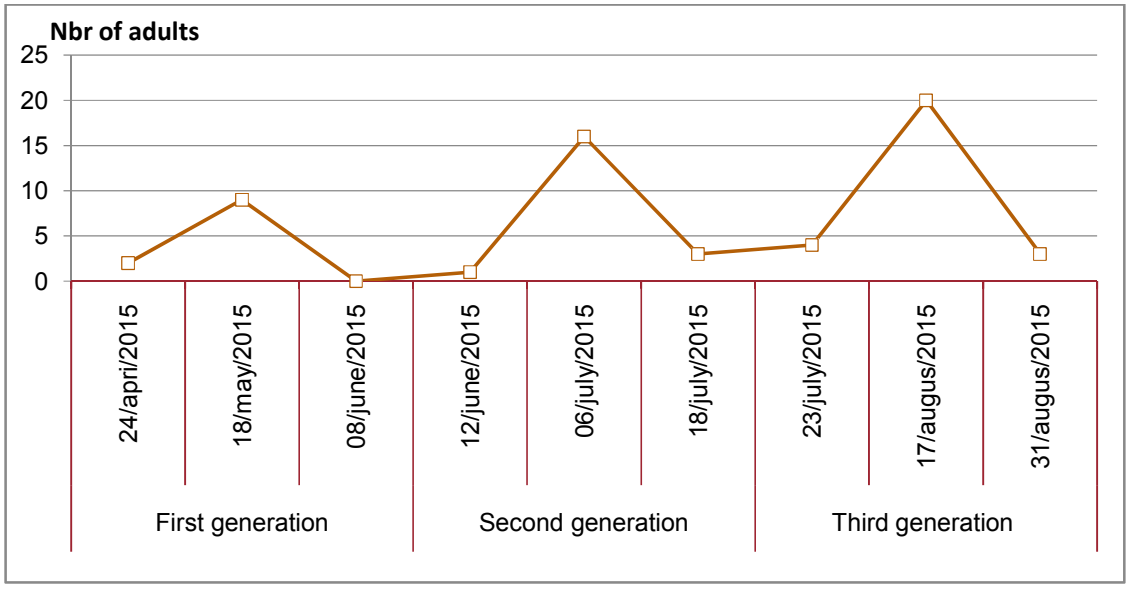

Figure 2: Flight of Adults codling moth in the region of Tadmait.

The inventory of the entomo fauna allowed us to capture 42 species divided into 29 families, belonging to 7 orders (Table 1). The results recorded are exploited by ecological indices of composition and structure.

Table 1: **Representative table of insect species captured by the different sampling techniques in the study plot.**

Order	Family	Species	Colored traps	Barber traps	Sweep net
Nevroptera	Chrysopidae	*Chrysoperla carnea*	6	0	0
Hymenoptera	Apidae	*Apis mellifera*	4	1	6
		Panurguscalcaratus	0	0	3
		Eucera sp	1	0	0
	Andrenidae	*Andrena labiata*	3	0	0
	Eupelmidae	*Eupelmus sp*	0	0	7
	Megachilidae	*Megachilefertoni*	0	0	2
	Formicidae	*Messor barbarus*	0	10	0
		Messor structor	0	3	0
		Cataglyphis bicolor	0	21	0
	Vespidae	*Polistes gallicus*	0	0	8
	Scoliidae	*Dasyscoliaciliata*	2	0	0
Diptera	Culicidae	*Culex pipiens*	5	0	18
	Syrphidae	*Eristalis tenax*	0	0	5
		Melanostoma mellinium	0	0	2
		Episyrphus balteatus	3	0	0
	Tephritidae	*Ceratitis capitata*	13	0	0
	Sepsidae	*Sepsis cynipsea*	2	0	0
	Cecidomyiidae	*Aphidoletes aphidimyiza*	0	0	6
Coleoptera	Coccinellidae	*Hispaalgerica*	1	0	0
		Hyppodamia variegata	3	0	4
		Psyllobora sp	0	0	2
	Curculionidae	*Lixus sp*	5	0	0
	Apionidae	*Apion pomonae*	7	0	0
	Cetoniidae	*Oxytheria funesta*	8	0	6
	Carabidae	*Macrothoraxmorbilusus*	0	8	0
		Carabus auratus	0	28	0
	Scarabaeidae	*Scarabaeus sp*	0	8	0
		Rhysotrogus maculicolis	0	23	0
	Chrysomelidae	*Chrysolina americana*	4	0	0
	Cicindellidae	*Cicindella campestris*	0	4	0
	Elateridae	*Agriotes sp*	0	2	0
Heteroptera	Lygaedae	*Nysiu ssp*	3	0	17
	Pyrrocoridae	*Pyrrocoris apterus*	0	18	0
	Pentatomidae	*Aelia sp*	3	0	0

		Nezra viridula	2	0	5
Homoptera	Aphididae	*Aphis fabae*	22	0	16
		Aphis neri	5	0	1
		Aphis citricola	7	0	10
Orthoptera	Acrididae	*Calliptamus italicus*	0	5	0
	Grillidae	*Grillus campestris*	0	22	0
	Oedipodidae	*Oedipod acharpentieri*	0	4	0
Total	**29**	**42**	**108**	**157**	**118**

The total wealth of the species caught using the different sampling methods are expressed in the table 2.

Table 2: Total wealth of the species caught by the different sampling methods in the study plot

Trap type	**Sweep net**	**Barber traps**	**Coloredt raps**
Total wealth(S)	S= 17	S= 14	S= 21

The total wealth of the species harvested by using of the three methods of capture in prospected plot is depending on the type of trap employed. The total wealth is 21 species using the colored traps; she is 17 species by using the sweep net and 14 species by use Barber traps.

Relative abundances of insect species captured by the use of the three sampling methods (sweep net, colored traps and Barber traps) are illustrated in figures 3, 4, and 5.

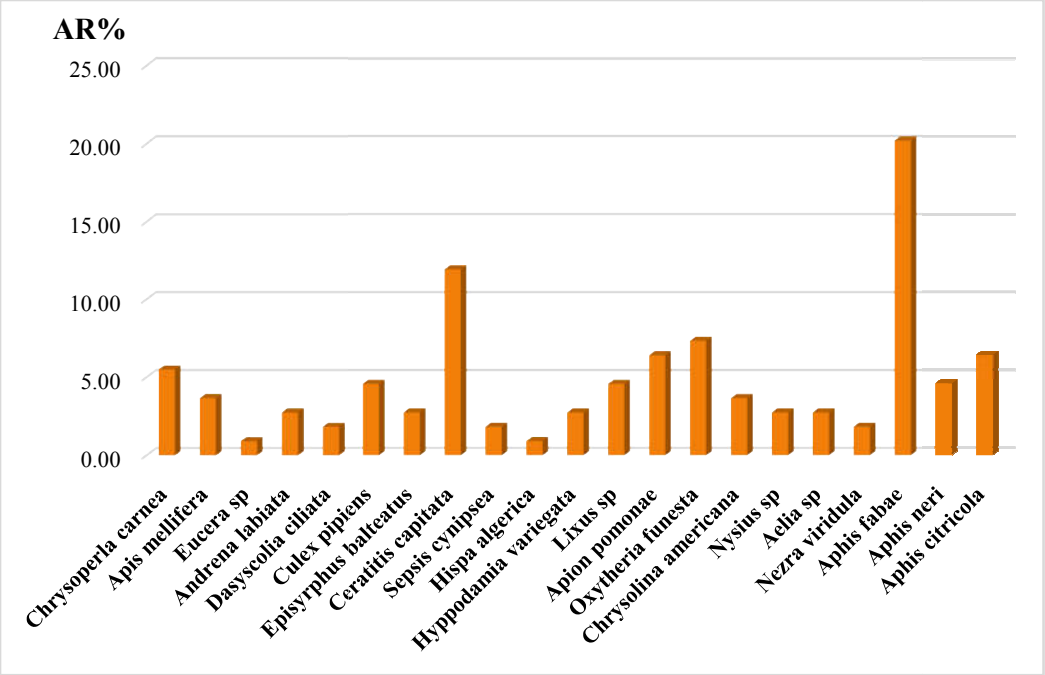

Figure 3: Centesimal frequencies of the species caught in the study plot by use colored traps.

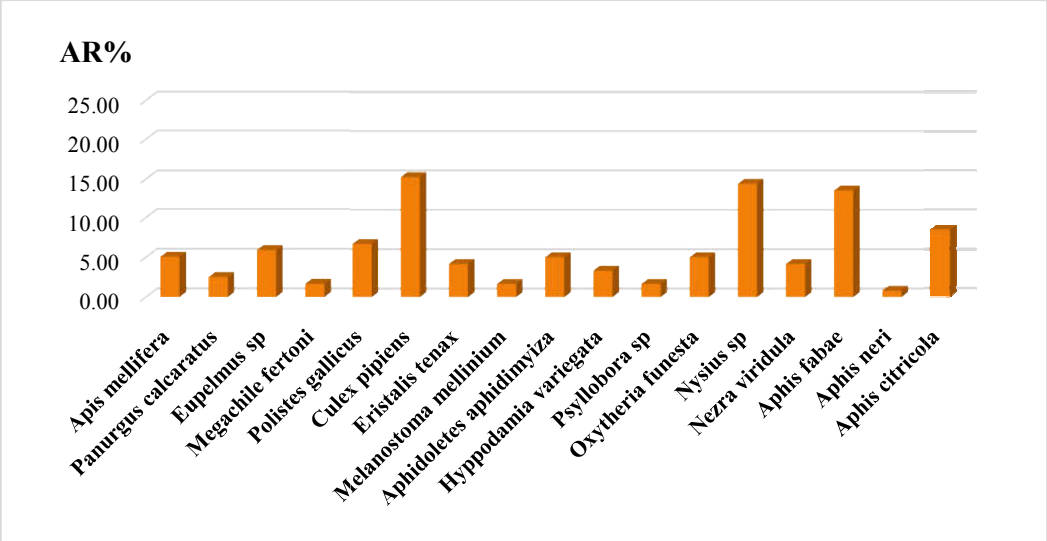

Figure 4: Centesimal frequencies of the species caught in the study plot by use sweep net.

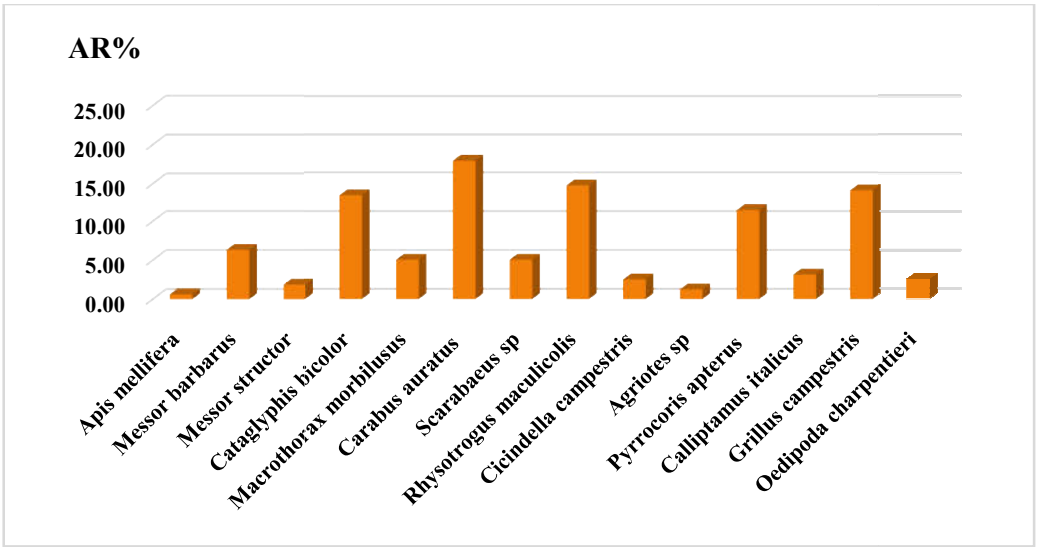

Figure 5: Centesimal frequencies of the species caught in the study plot by use Barber traps.

We find that the species best represented by the use of colored traps is *Aphis fabae* with a relative frequency of 20,18%, followed by *Ceratitis capitata* with a percentage of 11,92%, the species *Hispa algerica* and *Eucera sp* are represented with low values of 0,92%.We find that the species best represented by the use of sweep net is *Culex pipiens* with a relative frequency of 15,25%, followed by *Nysius* sp with a percentage of 14,41%, species *Aphis neri* is represented with a low value of 0,85%.We find that the species best represented by the use of Barber traps is *Carabus auratus* with a relative frequency of 17,83%, followed by *Rhysotrogus maculicolis* with a percentage of 14,65%, species *Apis mellifera* is represented with a low value of 0,64%.

Insect diets are extremely diverse, because of the structures and functioning of the mouthparts, of the structural and functional division of the digestive tract (Beaumont et cassier, 1983). Thus, we have established a distribution according to different trophic categories according to our personal observations and the consulted bibliography. We have been able to distinguish 6 large sets from the 42 selected insect species.

The distribution of insect species caught according to their trophic levelusing three sampling methods (sweep net, colored traps and Barber traps) is illustrated in figures 6, 7 and 8.

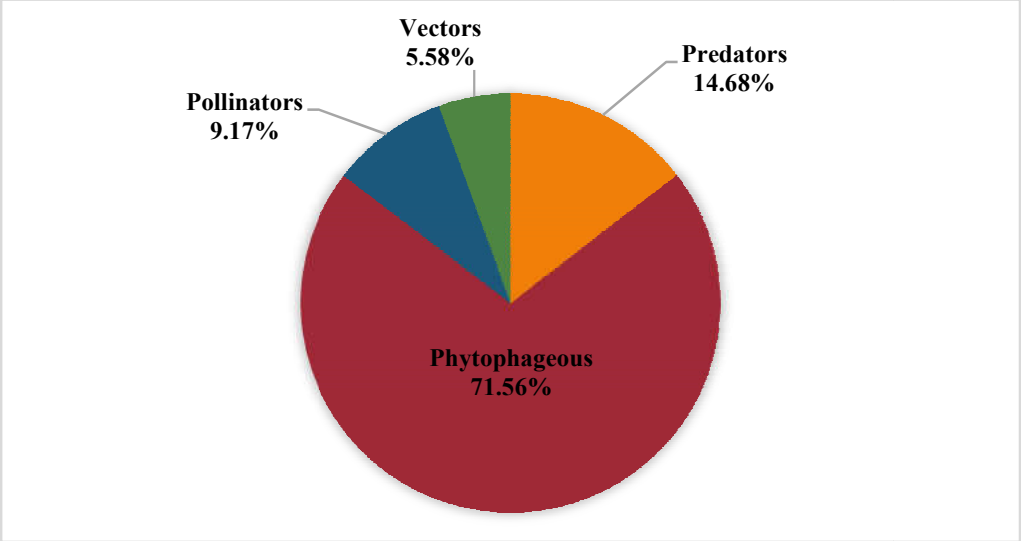

Figure 6: Centimesimal frequencies of the species caught according to their trophic regimes by use of colored traps.

We find by the use of this method of trapping a strong representation of phytophages; largest group with 71.56% captured insects. Predators are represented with a percentage of 14.68%, pollinators and vectors account for low rates with respectively 9.17% and 5.58% of the total catch.

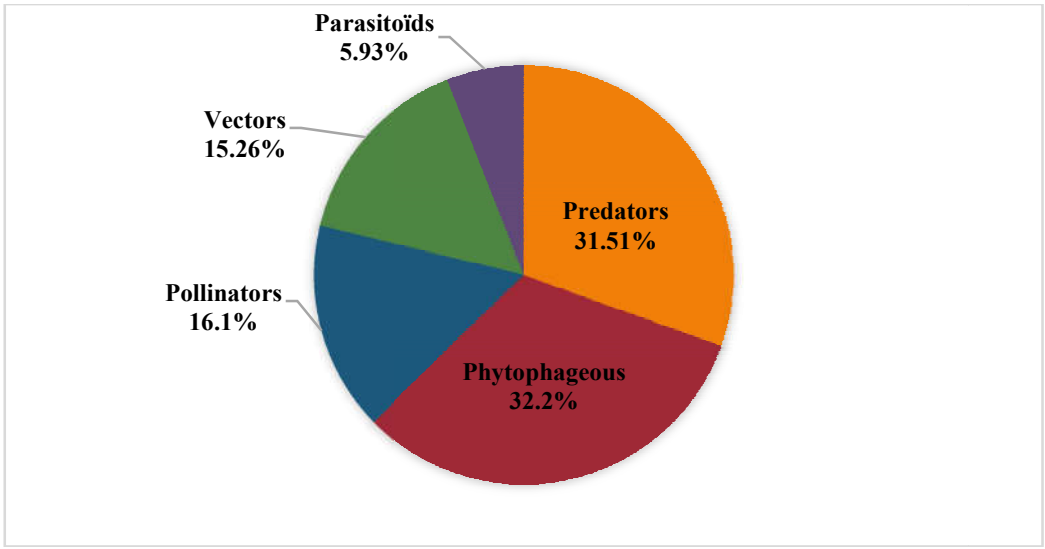

Figure 7: Centimesimal frequencies of the species caught according to their trophic regimes by use sweep net.

We find by the use of this method of hunting (sweep net) with respectively 32.2% and 31.51%. Next come pollinators and vectors with respectively 16.1% and 15.26%, parasitoids are harvested and account for low rates with 5.93% of the total catch.

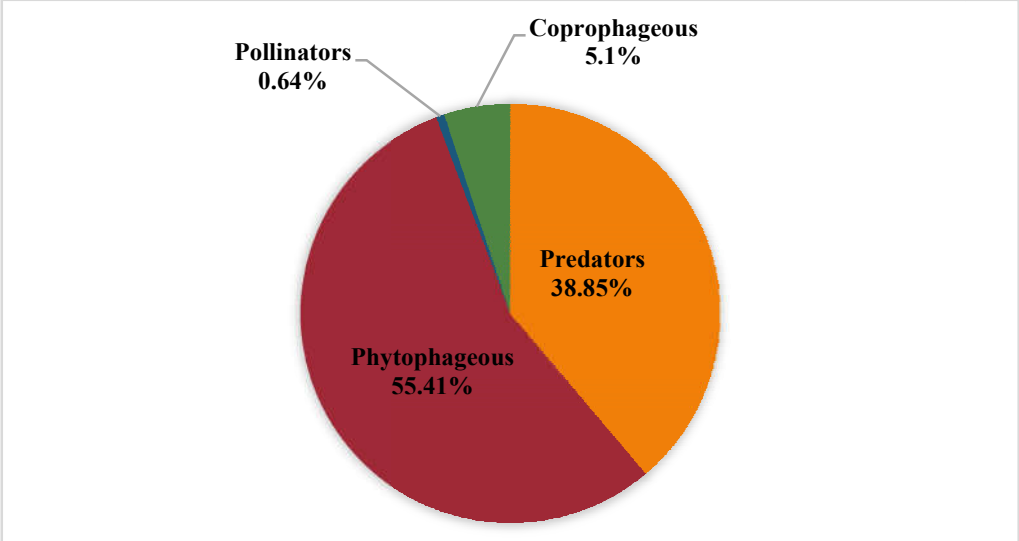

Figure 8: Centimesimal frequencies of the species caught according to their trophic regimes by use Barber traps.

We observe by the use of this method of trapping a strong representation of phytophages followed by predators; with respectively 55.41% and 38.85%. Next come the coprophages with a centesimal frequency of 5.1%, pollinators account for relatively low rates with 0.64%, making them the least rich groups.

Results from Shannon-Weaver Diversity Indexes (H'), maximum diversity (H'max) and equitability (E) applied to arthropod species sampled by different types of traps in the different study plots are illustrated in the table 3.

Table 3: Shannon-Weaver H 'diversity values and equitability of the species caught using the different sampling methods in the study plot

Trap type	Sweep net	Barbertraps	Coloredtraps
H' (bits)	3.73	3.36	3.98
H' max (bits)	4.10	3.82	4.41
E	0.91	0.89	0.90

The Shannon-Weaver Diversity Index values are quite high, they are from H'= 3.36bits by using Barber traps, H'= 3.73 bits by using sweep net and H'= 3.98 bits by using colored traps.

The equitability obtained for each type of trap varies from E= 0.89 to E= 0.91, these values tend towards 1, which reflects a balance between the species of the environment.

4. DISCUSSION

Adult flight curves of codling moth *C. pomonella* are the result of catches of males by use of sexual traps using a specific pheromone diffuser (E,E)-8,10-Dodecadien-1-ol. The periods activity of codling moth, reveal the existence of three periods of flight for five months, from April to August in the study plot.

Our results corroborate those of Kherraf (1991), Bouhidel (1992), Razi (1997), Belkadi andHamli (1998), those available in the SRPV of Ain-Touta for the years 2004, 2005 and 2006 and Chafaa (2008), which revealed the existence of three generations per year, with a flying activity spread between the

beginning of April and the end of September see the beginning of October. On the other hand, in Tunisia, Gabtini (1995) reports 3 to 4 generations. In France, Ramade (1984) and Toubon (2008) found that there is an evolution of codling moth populations and referral to a viable third generation in the South and a second generation in the North. Otherwise, Mansour and Mohamed (2000) used in Syria sexual traps as a means of combating *C. pomonella* which reduced the number of interventions from 6 to 2 for pesticides.

The study of entomo fauna on apple growing in Tadmait region (Tizi-Ouzou) identified 42 species in 29 families belonging to 7 orders.

Aberkane-Ounas (2013), in his study of the entomofauna in the vineyards in Tizi-Ouzou identified 99 species of insects distributed in 46 families and 11 orders. Diaband Deghiche (2014) have identified 14 species belonging to 14 families grouped into 8 orders. Allili (2008) mentions 23 species belonging to 19 families divided into 8 orders of 3 classes, in a pear orchard in Birtouta (Alger).

Souttouand *et al*. (2006) in a study on the biodiversity of arthropods in natural environments in the palm grove of Oued Sidi Zarzour in Biskra, reported total wealth equal to 70 arthropod species. Merabet (2014) estimated the total wealth to S = 74 using Barber traps in Agni N Smen. Frahand *al*. (2015) during his study on arthropodological fauna in Sefiane (Batna) estimated the total wealth to S = 71 using Barber traps, S = 63 using colored traps, and S = 54 using sweep net.

Merabet (2014) in his arthropod inventory at Agni N Smen reports dominance of the species *Messor barbarus* with a centesimal frequency equal to 19.16% using Barber traps. Mezani and *al*. (2016) showed a dominance of the species *Aphis fabae* with a value equal to 17.84% using colored traps. Guermah and Medjdoub-Bensaad (2016) report a dominance of the species *Apis mellifera* with a centesimal frequency equal to 13.96% using weep net.

According to the trophic regime of arthropods, Achouraand Belhamra (2010) have noted five groups whose phytophageous are best represented with 56.25%. They are followed by predators with 20.83%, saprophageous with 18.78% and finally parasits and polyphageous with 2.08%. Diaband Deghiche (2014) indicate a dominance of phytophageous with 53%, followed by predators with 35%, then the polyphageous with 12% in an olive growing in Sahara region. Guettala-Frah (2009), in his study on the economic impact and bioecology of the main apple pests in the Aurés region, have recorded 69.72% of phytophageous, followed by predators and parasitoids with a percentage equal to 15.98%, and 4.76% respectively. Finally, saprophages, necrophages and coprophages represent low percentages of 3%.

According to Blondel (1979), a community is even more diverse as the diversity index is higher. The variations in the values of the Shannon index are explained by N'zala and *al*., (1997) who reported that if the living conditions in a given environment are favorable, we observe many species each of them is represented by a small number of individuals. If the conditions are unfavorable we find that a small number of species each of them is represented by a large number of individuals. Barbaultin (1981) adds that the amount of plant species available intervenes on animal wealth. So the insect community is related to architecture, the amount of the plant and at the diversity of ecological niches.

Guermah and Medjdoub-Bensaad (2016) report a diversity of Shannon-Weaver equal to H = 4.31 bits with maximum diversity equal to H max = 6.64 bits applied to arthropods sampled by the use of sweep neton appel plot in Tizi-Ouzou region. Frah and *al*. (2015) during his study on arthropodo fauna in an olive plot in Sefiane (Batna) report a value of diversity equal to H = 4.7 bits, Hmax = 6.1 using Barber traps; H = 4.6 bits, Hmax = 6 using colored traps and H = 5.2 bits, Hmax = 5.8 using sweep net report a value of diversity equal to Guettala-Frah (2009) during a faunistic inventory on apple trees made in the Aurès with a value equal to E= 0.44 for the auxiliaries of the station of Ichemoul, and also by Belmadani and. *al*. (2014) in a study of the distribution of arthropods in pear

orchard Tadmait with a value equal to E= 0.3. Ounisand.*al*. (2014) found equitability varying from 0.12 to 0.47. Guermah and Medjdoub-Bensaad (2016) registered equitability of 0.65.

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