

DIVERSITY, STRUCTURE AND COMPOSITION OF SCALE INSECTS POPULATIONS (HOMOPTERA: COCCOIDEA) ON CITRUS IN KABYLIA, ALGERIA

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ABSTRACT

Ten species of mealybugs (Homoptera, Coccoidea) were inventoried in Kabylia on various citrus species, which are: lemon, Clementine, Thomson orange and washingtonorange during two-years, from March 2014 to March 2016. They belong to the four families: the Diaspididae, the Coccidae, the Pseudococcidae and the Margarodidae. This study allowed us to demonstrate the presence of a new species of cochineal (Coccidae: *Coccus pseudomagnoliarum* Kuwana) in Algeria and also to report for the first time in Algeria the presence of *Ceroplastesrusci* on citrus. The relative abundance calculated for the families and the inventoried species showed a strong dominance of the Diaspididae family with (90.3%) and *Parlatoriaaziziphi* is the pest species that predominates in Kabylia with an average of 76.3% followed by *Aonidiellaaurantii* with an average of 7.3%. The application of ecological concepts on the populations of mealybugs in our study is the first in Algeria. Equal distribution of cochineal species is minimal, which shows that *Parlatoriaaziziphi* is an omnipresent or dominant species and that *Ceroplastesrusci* is a very rare species on citrus and sometimes accidental.

KEYWORDS: Diversity, Coccoidea, Distribution, Citrus, Orchard, Kabylia

INTRODUCTION

The mealybugs (Homoptera: Coccoidea) are one of the largest Homoptera superfamilies that forms a relatively small group of insects in terms of species richness, and includes 32 families (Takumasa et al., 2008), spread around the world (Simon and Zyla, 2015). These are separated into two groups: the Neococcoids (Koteja and Azar, 2008), and the Archaeococcoids (Koteja, 2008). These two groups are divided into several families, morphologically very different: Diaspididae (2437 species), Pseudococcidae (2200 species), Coccidae (1117 species) and Margarodidae (375 species) (Ricard et al., 2012).

According to Takumasa et al., (2008) mealybugs are an interesting group to study. They are important pests of agriculture (Miller et al., 2005), fruit plants, ornamental plants (Khosla et al., 2006) and woody plants (Rasekh et al., 2011). Mealybugs can cause economic damage to plants as a result of their sucker-sucker feeding to feeding on plant sap practices (Gullan and Steffan 2003; Bonani et al., 2010) (Koga et al., 2012; Takumasa et al., 2008), constitute a group of pests which are particularly dangerous for citrus fruits, both because of the depreciations they cause to the fruits and by the weaknesses which they cause on the tree where they are abundant (Loussert, 1989; Franco et al., 2004). Their mere presence depreciates the quality of fruits.

The objective of this study is to make an inventory of the main citrus pests in Kabylia, namely mealybugs (Homoptera: Coccoidea), with an interest in their diversity, structure and even distribution of citrus fruits. In Algeria, despite the importance of these insects, few studies have been conducted on their diversity and distribution. The inventory work on the Coccidae which began in 1867 by Biosduval and others until 1911 when Dr. Trabut gave the first insight into the North African fauna by publishing his "Catalog of mealybugs observed in Algeria". They were pursued by Balachowsky (1926-1958) and Benassy (1975). More recently, we have the work of Belguendouz and Biche (2015) realized from 2003 to 2005. In Kabylia few studies have been done on the Coccoidea. Only a few areas of Kabylie were cited by Balachowsky (1927) in his contribution to the study of the Coccides of Minor Africa, namely Azazga and Yakouren. This motivated our choice to carry out this inventory and study the structure and composition of stands of the scale of citrus.

MATERIAL AND METHODS

Study Area

This study is carried out in Kabylia (Tizi-Ouzou), distant about 100 km from the capital Algiers (Algeria), in eight citrus orchards divided into four communes: Freha, Ouagnoun, irdjen, and Tizi-Ouzou. In the latter, we worked in two stations which are Chamlal and Chabane (Figure 1). The study is made on three species of citrus fruits: Clementine (*Citrus climentina*), lemon (*Citrus Limon* var. Eureka), and orange (*Citrus sinensis* varieties Thomson and Washington), for two years, from March 2014 to March 2016.

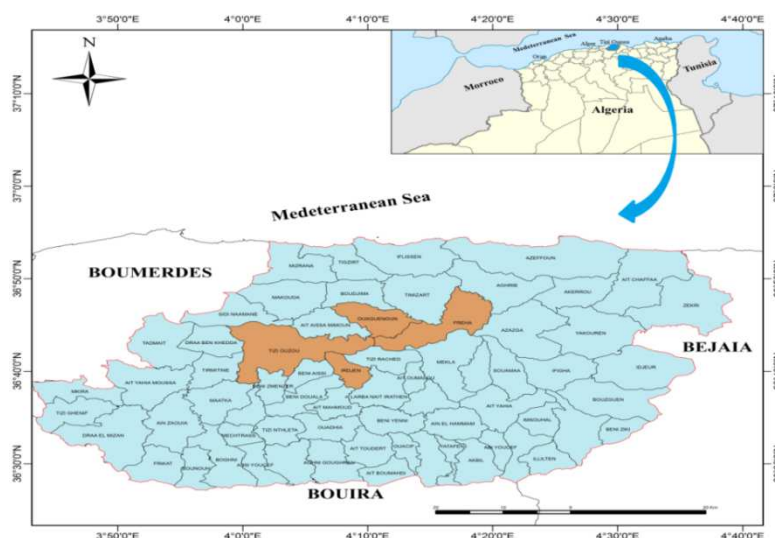


Figure 1: Geographical Situation of Kabylia (Tizi-Ouzou) and Location of Study Stations

Collecting Scales Insects

The experimental unit, in each orchard, corresponds to a parcel of 250 trees divided into 9 blocks of 25 trees for each block. Two trees are chosen randomly in each block and will be the same sampled in order to obtain a homogeneous sampling. Collecting mealy bugs involves taking a twig with two leaves for each cardinal direction and at the center of the tree to be sampled. The samples are labeled with the date, plant species and study area. In the laboratory samples are examined carefully using a binocular lens. The number of individuals of each species of cochineal inventoried will be reported on sampling sheets specific to each orchard and to each region.

Data Analysis

To exploit the results obtained in this study, we used different ecological indices, calculated for all inventoried species. The computed composition indices are mean specific richness (S), relative abundance (AR) and frequency of occurrence (C). The structural indices are the Shannon-Weaver diversity index (H') and the Pielou fairness index (J).

RESULTS

The Species of Cochineal Inventoried

The examination of 77.760 samples for the inventory of citrus scales in Kabylia (Tizi-Ouzou) revealed the presence of 10 species of cochineal (Homoptera: Coccoidea) belonging to eight genera and four families (Table 1). The family Diaspididae with four species and three genera: *Parlatoriaziziphi* (Lucas), *Parlatoria pergandii* Comstock, *Chrysomphalus dictyospermi* (Morgan) and *Aonidiella aurantii* (Maskell), the family Coccidae is represented by four species and three genera: *Ceroplastes rusci*, *Saissetia oleae* Olivier, *Coccus hesperidum* L. and *Coccus pseudomagnoliarum* Kuwana. The latter is a new species of cochineal inventoried in Algeria. The families of Pseudococcidae and Margarodidae are represented by a single species, namely *Planococcus citri* (Risso) and *Icerya purchasi* Maskell respectively. This inventory allowed us to report the presence of *Ceroplastes rusci* for the first time on citrus in Algeria.

Table 1: List of Cochineal Species Inventoried in Kabylia (Tizi-Ouzou) on Citrus from March 2014 to March 2016

Family	Region	Irdjen			Tazmalt	Chabane		Freha	Chamlal
		Thomson Orange	Lemon	Clementine	Thomson Orange	Thomson Orange	Lemon	Washington Orange	Clementine
SDiaspididae	<i>Parlatoriaziziphi</i> (Lucas)	+	+	+	+	+	+	+	+
	<i>Parlatoria pergandii</i> Comstock	+	+	+	+	+	+	+	+
	<i>Chrysomphalus dictyospermi</i> (Morgan)	+	+	+	+	+	+	+	+
	<i>Aonidiella aurantii</i> (Maskell)	+	+	+	+	+	+	+	+
Coccidae	<i>Saissetia oleae</i> Olivier	+	+	+	+	+	+	+	+
	<i>Coccus hesperidum</i> L.	+	+	+	+	+	+	+	+
	<i>Coccus pseudomagnoliarum</i> Kuwana	-	+	+	-	+	+	+	+
	<i>Ceroplastes rusci</i> (L.)	+	-	+	+	+	+	-	+
Pseudococcidae	<i>Pseudococcus citri</i> (Risso)	+	+	+	+	+	+	-	+
Margarodidae	<i>Icerya purchasi</i> Maskell	+	+	+	+	+	+	+	+

(+): Presence, (-): Absence

Relative Abundance of Families Inventoried

The relative abundance calculated for Coccoidea (Homoptera) families inventoried on citrus in Kabylia highlighted the predominance of the Diaspididae family (Figure 2) with an average of 90.3%, followed by Coccidae (7.5%)

and The Margarodidae in third position (1.2%). The least represented family is Pseudococcidae (1.0%).

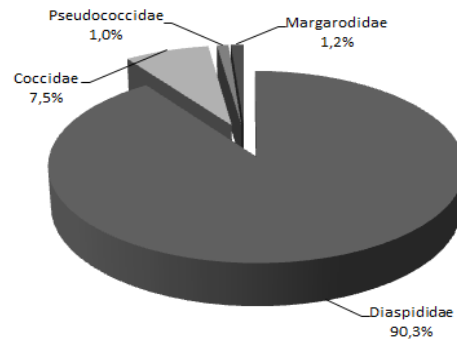


Figure 2: Relative Abundance of Coccoidea (Homoptera) Families Inventoried on Citrus in Kabylia from March 2014 to March 2016

Relative Abundance of Cochineal Species Inventoried

The centesimal frequency of the ten species of mealybugs found in the eight citrus orchards of the Tizi-Ouzou on lemon, orange and Clementine shows a strong dominance of the species *Parlatoriaziziphi* it constitutes the main pest of citrus fruits in Kabylia with an abundance of 76.3% (Figure 5-10). This species can be a secondary pest of citrus (Figure 3 and 4) when the orchard is invaded by another species of cochineal, the case of the Washingtonorange orchard of Freha where *Coccus pseudomagnoliarum* is larger (47.9%) and the orchard of Tazmalt, which is dominated by *Aonidiellaaurantii* (41.9%). Except for the Thomson orange orchards and the Washington orange in the Tazmalt and Freha regions, where *Parlatoriapergandii* occupies the second position after *Parlatoriaziziphi* (76.3%) with an abundance of 4.5% (Figure 6-10). Other cochineal species are poorly present.

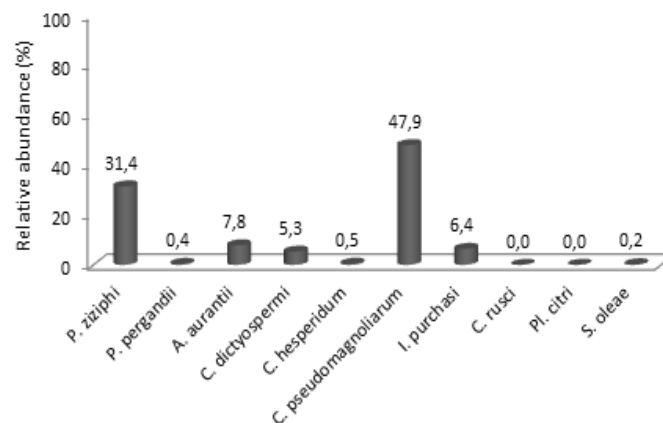


Figure 3: Relative Abundance of Cochineal Species Inventoried in the Washington Orange Orchard in Freha from March 2014 to March 2016

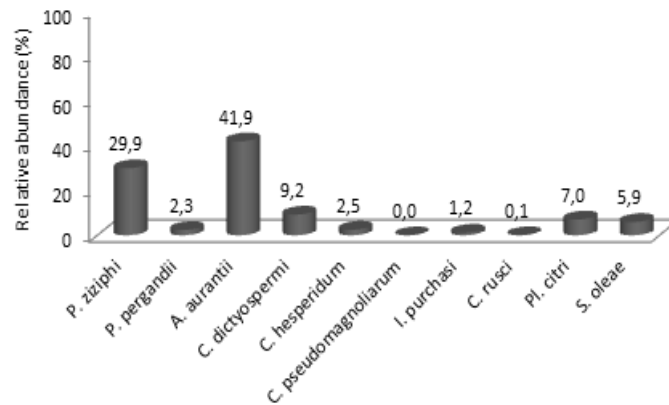


Figure 4: Relative Abundance of Cochineal Species Inventoried in the Thomson Orange Orchard in Tazmalt from March 2014 to March 2016

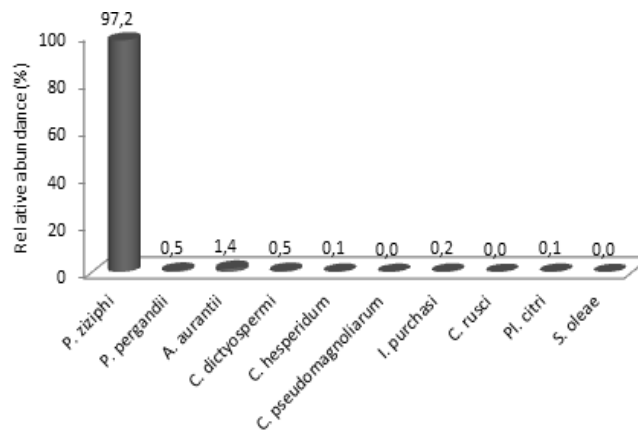


Figure 5: Relative Abundance of the Cochineal Species Inventoried in the Lemon Orchard in Irdjen from March 2014 to March 2016

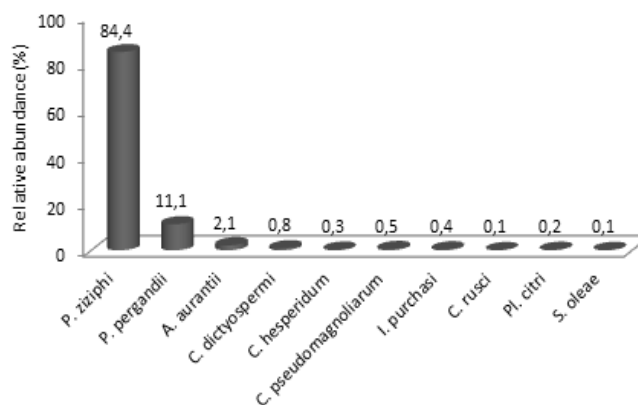


Figure 6: Relative Abundance of Cochineal Species Inventoried in the Chabane orchard Lemon from March 2014 to March 2016

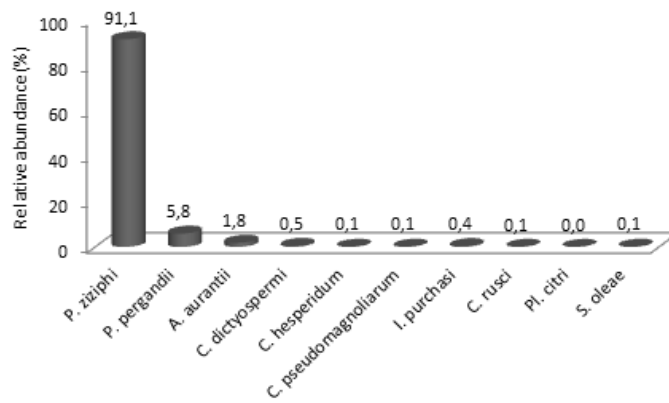


Figure 7: Relative Abundance of Cochineal Species Inventoried in the Clementine Orchard in Chamla from March 2014 to March 2016

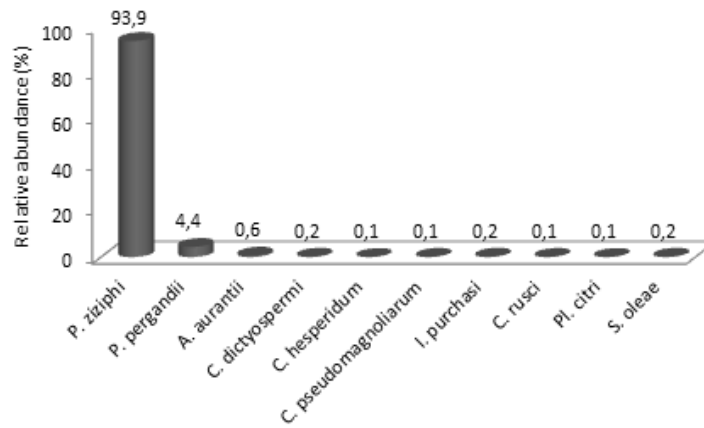


Figure 8: Relative Abundance of Cochineal Species Inventoried in the Clementine Orchard in Irdjen from March 2014 to March 2016

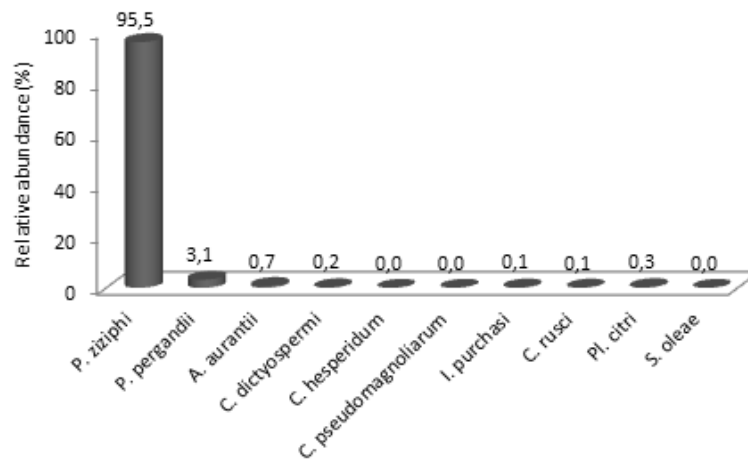


Figure 9: Relative Abundance of Cochineal Species Inventoried in the Thomson Orange Orchard in Irdjen from March 2014 to March 2016

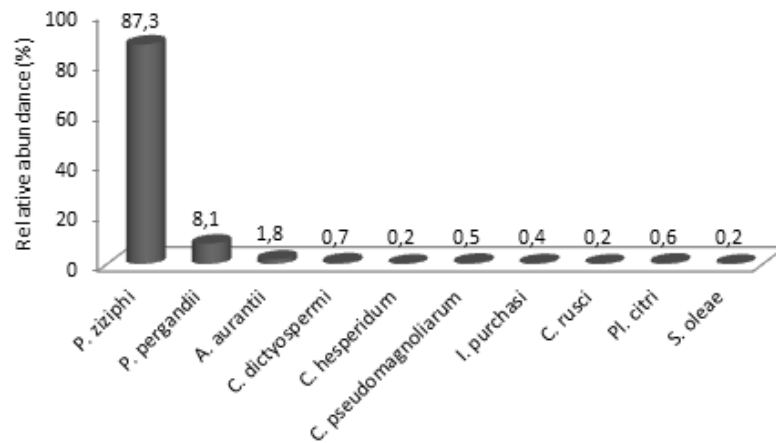


Figure 10: Relative Abundance of Cochineal Species Inventoried in the Chabane Orchard Thomson Orange from March 2014 to March 2016

Structure and Organization of Mealy Bug Populations Specific Wealth

Figure 11 shows that the Chabane orchards of Thomson and lemon trees and the Clementine orchards of the Chamlal and Irdjen regions harbor the maximum number of cochineal species, reaching a wealth of 10 species. However, the highest average wealth is recorded in the chabane orchards of lemon and Thomson orange.

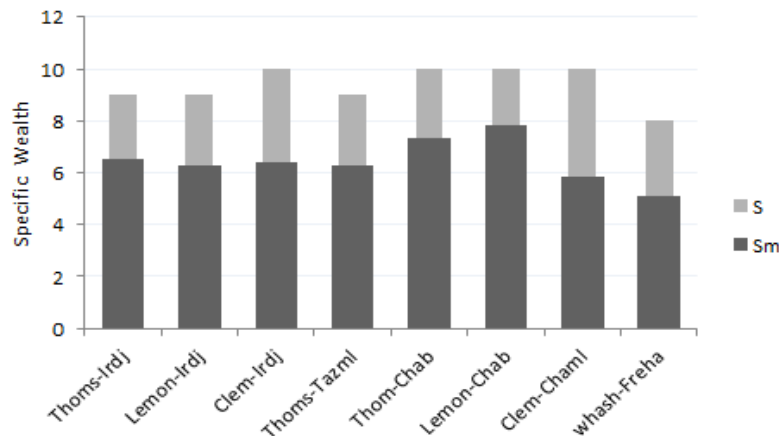


Figure 11: Specific Wealth (S) and Specific Wealth Averages (Sm) of Eight Orchards of Citrus Studied In Kabylia from March 2014 to March 2016

Frequency of Occurrence (Constancy)

The application of the concept frequency of occurrence or the constancy of the cochineal species recorded in the four stations made it possible to define six classes (Table 2). Thus, *Parlatoriaziziphi* is omnipresent in the orchards of Irdjen, Chamlal and Chabane. The species *Coccus hesperidum* and *Saissetiaoleae* are accidental in the orchards of Clementine and lemon of Irdjen, those of Washington orange of Freha and the Clementine of Chamlal but are accessory in the Chabane orchards and the Thomson orange orchard of Tazmalt. *Iceryapurchasi* is regular in all the citrus orchards studied in Tizi-Ouzou. The rare category is represented by the species *Ceroplastesrusci*.

Table 2: Frequency of Occurrence and Category of Cochineal Species Inventoried in the Eight Citrus Orchards Studied in Kabylia from March 2014 to March 2016

Region Variety Species	Irdjen						Tazmalt		Chabane				Chamlal		Freha	
	Thomson Orange		Lemon		Clementine		Thomson Orange		Thomson Orange		Lemon		Clementine		Washington Orange	
	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat
<i>Parlatoriaziziphi</i>	100	Om	100	Om	100	Om	86,1	C	100	Om	100	Om	100	Om	41,6	A
<i>Parlatoriapergandii</i>	100	Om	47,2	A	94,4	C	22,2	Ac	86,1	C	94,4	C	86,1	C	55,5	Rg
<i>Chrysomphalusdictyospermi</i>	50	Rg	5,55	Rg	50	Rg	86,1	C	52,7	Rg	55,5	Rg	36,1	A	5,5	Ac
<i>Aonidiellaaurantii</i>	91,6	C	86,1	C	36,1	A	100	Om	86,1	C	91,6	C	55,5	Rg	36,1	A
<i>Saissetiaoleae</i>	5,55	Rg	8,3	Ac	13,8	Ac	27,7	A	25	A	33,3	A	11,1	Ac	13,8	Ac
<i>Coccus hesperidum</i>	5,55	Rg	22,2	Ac	13,8	Ac	41,6	A	30,5	A	44,4	A	22,2	Ac	22,2	Ac
<i>Planococcus citri</i>	27,7	A	30,5	A	19,4	Ac	50	Rg	38,8	A	36,1	A	11,1	Ac	11,1	Ac
<i>Icerya purchasi</i>	61,1	Rg	66,6	Rg	72,2	Rg	50	Rg	69,4	Rg	69,4	Rg	55,5	Rg	55,5	Rg
<i>Ceroplastes rusci</i>	5,55	Rg	-		8,3	Ac	2,7	R	16,6	Ac	19,4	Ac	5,55	Ac	5,55	Ac
<i>Coccus pseudomagnolianum</i>	-		16,6	Ac	33,3	A	-		36,1	A	47,2	A	27,7	A	27,7	Ac

AR: Relative Abundance, C%: Constance, Cat: Category, C: Constant, R: Rare,

A: Accessory, Ac: Accidental, Om: Omnipresent, Rg: Regular

Diversity and Distribution of Stands Mealy Bugs

The highest Shannon-Weaver diversity index is recorded in the Thomson orange orchard of the Tazmalt region with 2.21 bits (Table 3) followed by that of a Frehawashington orange with 1.89 bits and an accountability index that tends to 1 in both orchards, this shows a good distribution of the individuals of all the listed cochineal species. The other citrus orchards have a very low diversity index, ranging from 0.24 bits in the lemon orchard of the Irdjen region and 0.87 bits in the chabanelemon orchard. The equitability index tends to zero, which explains why the scale populations are not balanced and dominated by a single species.

Table 3: Index of Diversity H' and Equitability of Mealy Bug Stands in Each Citrus Orchard at Kabylia

Region Orchard Index	Irdjen			Tazmalt	Chabane		Chamlal	Freha
	Thomson Orange	Lemon	Clementine	Thomson Orange	Thomson Orange	Lemon	Clementine	Washington Orange
H'	0,33	0,24	0,43	2,21	0,79	0,87	0,58	1,89
H'max	3,17	3,17	3,32	3,17	3,32	3,32	3,32	3
E	0,10	0,08	0,13	0,70	0,24	0,26	0,17	0,63
Sm	6,5	6,25	6,41	6,25	7,33	7,83	5,83	5,08

DISCUSSIONS

The inventory of mealybugs (Homoptera: Coccoidea) of citrus in Kabylia revealed the presence of 10 species belonging to the four families Diaspididae, Pseudococcidae, Coccidae and Margarodidae. This inventory shows a strong dominance of the family Diaspididae. According to Belguendouz and Biche (2015), the family Diaspididae is the most represented in Algeria with 118 species and four tribes, including Aspidiotini (*Aonidiellaaurantii* and *Chrysomphalusdictyospermi*) and Parlatorini (*Parlatoriaziziphi* and *Parlatoriapergandii*).

These same authors have reported that this family is represented by 6 species belonging to the genus *Parlatoria* counted on 72 vegetable taxa. This study has shown that *Parlatoriaziziphi* is a typical pest of citrus and predominates in all citrus orchards in Kabylia (Tizi-Ouzou). Indeed *Parlatoriaziziphi* is a cosmopolitan species that is widespread in the Maghreb countries (Gacem et al., 2016), such as Tunisia (Jendoubi et al., 2008) and Egypt (Tawfeek, 2007; Tawfeek and Amany, 2010). For their part, Podsiadlo and Bugila (2007) consider *Parlatoriaziziphi* as a pest specialized in citrus plants.

The most commonly encountered families are Diaspididae, Pseudococcidae, Coccidae (Takumasa et al., 2008), and Margarodidae (Gullan and Cook, 2007). They include the most dangerous species of citrus fruit (Gullan and Cook, 2007). However, in the citrus orchards in Kabylia, the Coccidae take the second place after the Diaspididae with an average of 7.5%. This family is the largest family of Coccoidea after the Diaspididae. It contains more than 1100 species grouped in more than 100 genera (Takumasa et al., 2008), of which *Coccus* is the oldest genus in the Coccidae (Avasthi and Shafee, 1991).

Coccus hesperidum, inventoried in this study, is reported to be an agent of serious economic losses to citrus growers in the United States (Williams and Aggarwal, 1980). *Coccus pseudomagnoliarum* (Kuwana) is a new species of cochineal (Homoptera, Coccidae) that we have inventoried in Algeria. It is identified by Professor Garcia Mari Ferran of the Polytechnic University of Valencia (Spain). This species, which was highlighted in our inventory, is considered as a major pest of citrus (Tena and Garcia Maori, 2008). This species was first described in 1972 in the Mediterranean basin, in several citrus producing countries, such as Syria (Mohamed et al., 2012), Italy (Tranfaglia, 1974), Turkey (De Lotto, 1973) and Spain (Tena and Garcia mari, 2008), and in other countries such as California (Trumble et al., 1995; Dreistadt, 1996) and Israel (Ben-Dov, 1980). Another species of the Coccidae, *Ceroplastesrusci*, Mediterranean cochineal (Balachowsky and Mesnil, 1935), was encountered in Algeria by Balachowsky (1932). This species is very widespread on the figure in Algeria (Sadoudi Ali Ahmed et al., 2011). In this study, we reported the presence on the Clementine, orange and lemon for the first time.

Parlatoriapergandii is the second species of citrus scales in Kabylia after *Parlatoriaziziphi*, which is in agreement with the work of states (2001) who observed the populations of ladybugs *Chilocorus bipustulatus* Linné and *Rhyzobiuslophanthae* Blaisdell on bitter orange heavily infested with *Parlatoriapergandii*

The citrus mealybug *Planococcus citri* listed in our inventory is considered an important pest of many ornamental and fruit crops especially citrus orchards. Pacheco da Silva et al., (2014) note that Pseudococcidae is one of the main factors limiting the export of grapes to Brazil. Among these Pseudococcidae, *Planococcus citri*, which is one of the important species of mealybugs present in vineyards (Daane et al., 2012) and which infests citrus fruits in South Africa (Malan and Niekerk, 2012).

From this work, two of the eight citrus orchards studied show a high diversity with a balanced distribution between scale populations. The other orchards are dominated by a single species. We can deduce that *Parlatoriaziziphi* is the most dominant species. The difference in diversity and distribution of populations of mealybugs between orchards and regions may be due to several factors that promote or limit the development of these species on citrus such as the physical and chemical characteristics of the plant, on the other hand, the influence of factors that climatic factors. Thus, Kaneko et al., (2015) deduced that the seasonal richness and abundance of carabid species in grassland and forest is very different, which has also been observed in some species of Chrysomelidae (Coleoptera) in sub-Saharan

Africa that have a preference for open places (Biondi et al., 2015). Similarly Mbete et al., (2011) report that mealy bugs attracted by the yellow color of mandarin fruit would appear more selectively on these host plants than on grapefruit and lemon trees whose fruits are green. For their part, Idder-Ighili et al., (2013) showed that the white cochineal *Parlatoria blanchardi* Targiono-Tozzetti evolved according to date varieties. They found that the Hamraya variety is more infested than the Tamsrit variety and they deduced that this may be due to the variable carbohydrate composition between varieties. This variation in the chemical composition of plants is an important factor in determining the interactions between pests and host plants (Golan and Agnieszka, 2011).

CONCLUSIONS

This study, which focused on the inventory of citrus mealybugs in Kabylia, allowed us to know the Coccidological fauna (Homoptera, Coccoidea) in the province of Tizi-Ouzou and to demonstrate the presence of a new species of cochineal in Algeria, which is *Coccus pseudomagnoliarum*. It also made possible to signal the presence of *Ceroplastes ruscif* for the first time on citrus in Algeria. Ten species of mealybugs belonging to the four families were inventoried in the four stations of eight orchards and three species of citrus. The Diaspididae family has been shown to predominate in all study stations. The ten listed cochineal species are important pests of crops in the world and in Algeria. We propose to complement this inventory with other works by using the biological control and to improve the management of the populations of these pests to protect our culture well.

ACKNOWLEDGMENTS

My sincere thanks to Professor D. Sadoudi Ali Ahmed for supervising and following the work, to Professor F. GARCIA MARI (University Polytechnic of Valencia, Spain) for his help, support, advice and for the identification of new cochineal species in Algeria thus the laboratory of the Insitute Agroforestal Mediterraneo of violence, Spain.

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