

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

HADDAD NORA & SADOUDI ALI AHMED DJAMILA

Pathology Laboratory Ecosystems, Faculty of Biological and Agricultural Science,  
Department of Biology, University Mouloud Mammeri Tizi-Ouzou, Algeria

### ABSTRACT

Ten species of mealybugs (Homoptera, Coccoidea) were inventoried in Kabylia on various citrus species, which are : lemon, Clementine, Thomson orange and Washington orange 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 *Ceroplastes rusci* 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 *Parlatoria ziziphi* is the pest species that predominates in Kabylia with an average of 76.3% followed by *Aonidiella aurantii* 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 *Parlatoria ziziphi* is an omnipresent or dominant species and that *Ceroplastes rusci* 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).

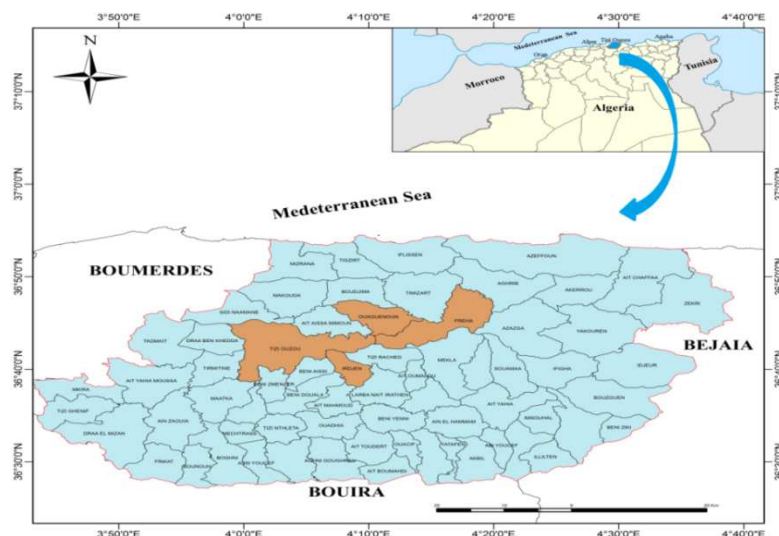
According to Takumasa et al., (2008) mealybugs are an interesting group to study. They are important pests of agriculture (Miller et al., 2005), fruit plants, ornamental plants (Khosla et al., 2006) and woody plants (Rasekh et al., 2011). Mealybugs can cause economic damage to plants as a result of their punchers-suckers feeding (Gullan and Steffan 2003; Bonani et al., 2010) for feeding on plant sap practices (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 Coccidea 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: *Parlatoria ziziphi* (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**

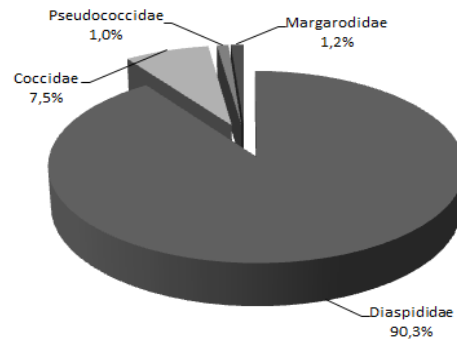
Family	Region Species of citrus Species of cochineals	Irdjen			Tazmalt	Chabane		Freha	Chamlal
		Thomson Orange	Lemon	Clementine	Thomson Orange	Thomson Orange	Lemon	Washington Orange	Clementine
Diaspididae	<i>Parlatoria ziziphi</i> (Lucas)	+	+	+	+	+	+	+	+
	<i>Parlatoria pergandii</i> Comstock	+	+	+	+	+	+	+	+
	<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%)

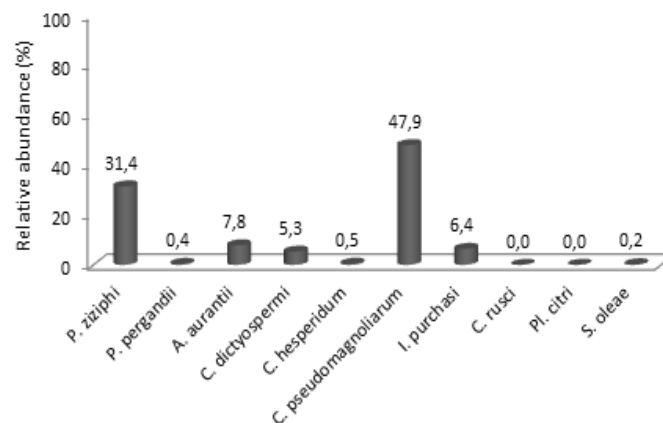
and The Margarodidae in third position (1.2%). The least represented family is Pseudococcidae (1.0%).



**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 *Parlatoria ziziphi* 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 Washington orange orchard of Freha where *Coccus pseudomagnoliarum* is larger (47.9%) and the orchard of Tazmalt, which is dominated by *Aonidiella aurantii* (41.9%). Except for the Thomson orange orchards and the Washington orange in the Tazmalt and Freha regions, where *Parlatoria pergandii* occupies the second position after *Parlatoria ziziphi* (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**

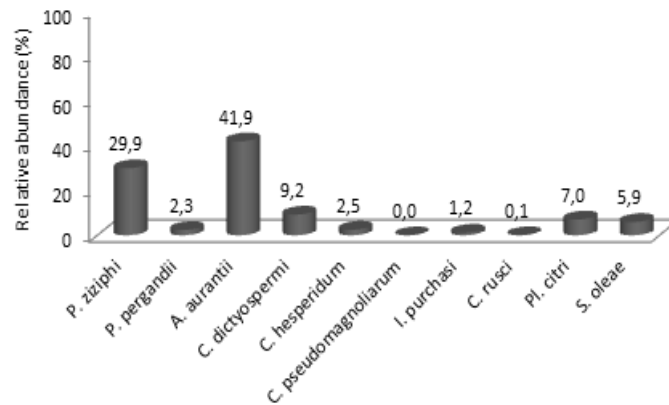


Figure 4: Relative Abundance of Cochineal Species Inventoried in the Thomson Orange Orchard in Tazmalt from March 2014 to March 2016

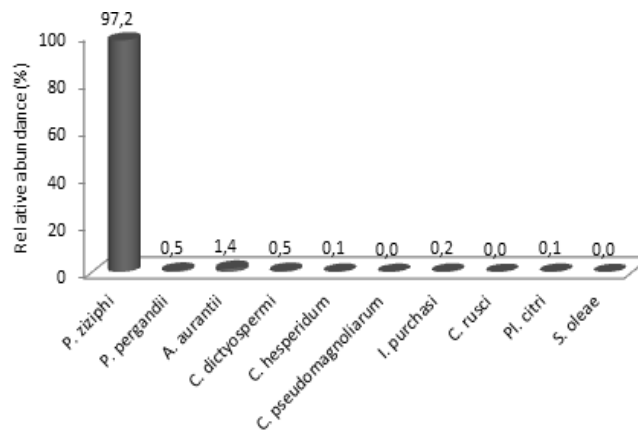


Figure 5: Relative Abundance of the Cochineal Species Inventoried in the Lemon Orchard in Irdjen from March 2014 to March 2016

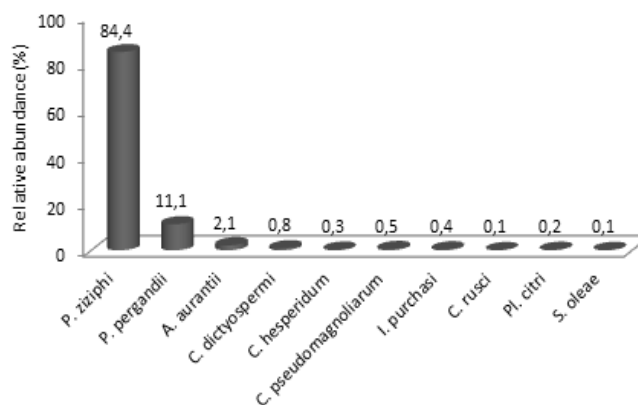
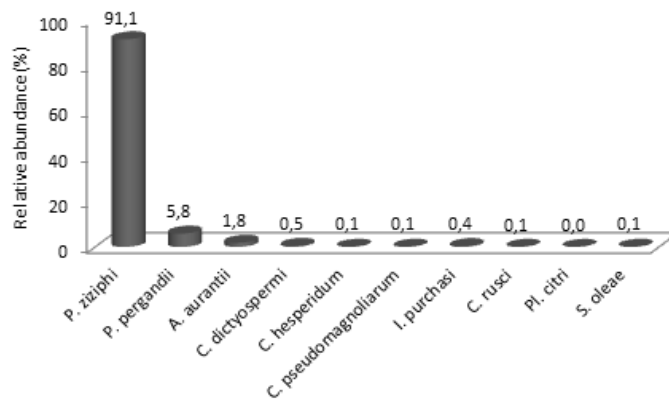
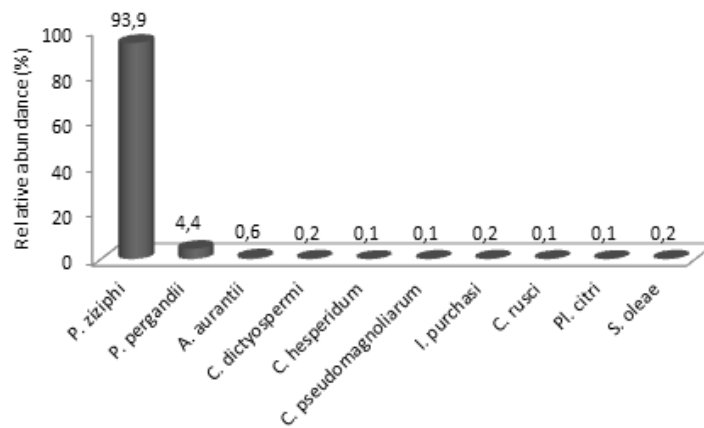


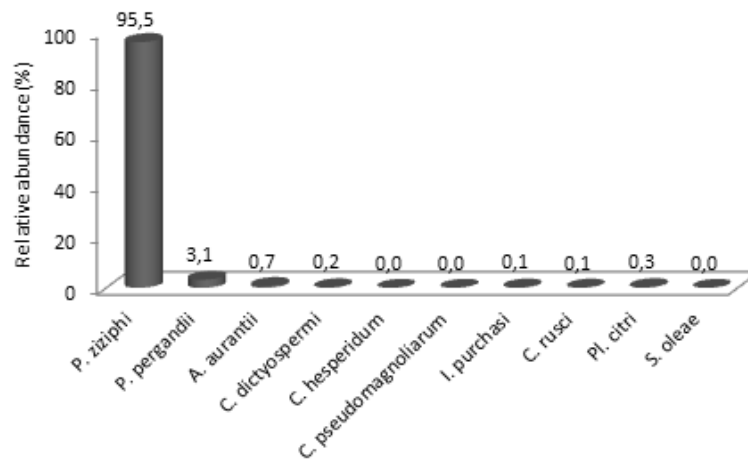
Figure 6: Relative Abundance of Cochineal Species Inventoried in the Chabane orchard Lemon from March 2014 to March 2016



**Figure 7: Relative Abundance of Cochineal Species Inventoried in the Clementine Orchard in Chamlal 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**

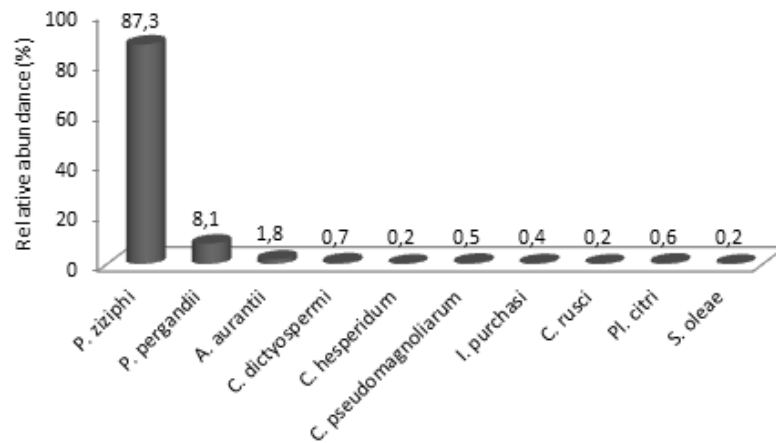


Figure 10: Relative Abundance of Cochineal Species Inventoried in the Chabane Orchard Thomson Orange from March 2014 to March 2016

### 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.

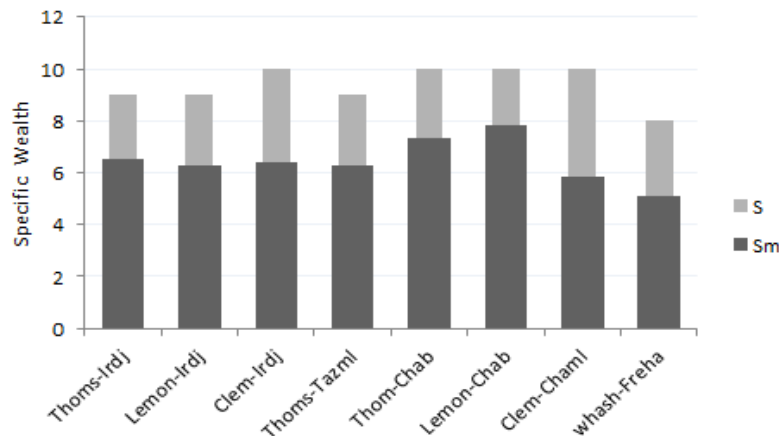


Figure 11: Specific Wealth (S) and Specific Wealth Averages (Sm) of Eight Orchards of Citrus Studied In Kabylia from March 2014 to March 2016

### 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, *Parlatoria ziziphi* is omnipresent in the orchards of Irdjen, Chamlal and Chabane. The species *Coccus hesperidum* and *Saissetia oleae* 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. *Icerya purchase* is regular in all the citrus orchards studied in Tizi-Ouzou. The rare category is represented by the species *Ceroplastes rusci*.

**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	Irdjen						Tazmalt		Chabane				Chamlal		Freha	
Variety	Thomson Orange		Lemon		Clementine		Thomson Orange		Thomson orange		Lemon		Clementine		Washington Orange	
Species	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat	C %	Cat
<i>Parlatoria ziziphi</i>	100	Om	100	Om	100	Om	86,1	C	100	Om	100	Om	100	Om	41,6	A
<i>Parlatoria pergandii</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>Chrysomphalus dictyospermi</i>	50	Rg	5,55	Rg	50	Rg	86,1	C	52,7	Rg	55,5	Rg	36,1	A	5,5	Ac
<i>Aonidiella aurantii</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>Saissetia oleae</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 pseudomagnoliarum</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 Freha Washington 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 Chabane lemon 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	Irdjen			Tazmalt	Chabane			Chamlal	Freha
Orchard	Thomson Orange	Lemon	Clementine	Thomson Orange	Thomson Orange	Lemon	Clementine	Washington Orange	
Index									
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 Diaspididae family is the most represented in Algeria with 118 species and four tribes, including Aspidiotini (*Aonidiella aurantii* and *Chrysomphalus*



*dictyospermi*) and Parlatorini (*Parlatoria ziziphi* and *Parlatoria pergandii*). 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 *Parlatoria ziziphi* is a typical pest of citrus and predominates in all citrus orchards in Kabylia (Tizi-Ouzou). Indeed *Parlatoria ziziphi* 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 *Parlatoria ziziphi* 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 Mari, 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, *Ceroplastes rusci*, 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.

*Parlatoria pergandii* is the second species of citrus scales in Kabylia after *Parlatoria ziziphi*, which is in agreement with the work of states (2001) who observed the populations of ladybugs *Chilocorus bipustulatus* Linné and *Rhyzobius lophanthae* Blaisdell on bitter orange heavily infested with *Parlatoria pergandii*.

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 *Parlatoria ziziphi* 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 mealybugs attracted by the yellow color of mandarin fruit would appear more selectively on these host plants than on grape fruit 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 rusci* 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 valencia, Spain.

## REFERENCES

1. Avasthi R.K & Shafee S.A., 1991. Revision of the genus *Coccus* Linn. in India (Insecta, Homoptera, Coccidae). *J. Bombay. Nat. Hist. Society.*, 88: 329-348.
2. Balachowsky A.S., 1926. Note on a Coccidae of the fauna Neotropical recently acclimatized and harmful to the fig tree in Algeria. *Bull. Soc. Hist. Nat. Afr. Nord.*, 1:63-69 [in French].
3. Balachowsky A.S., 1927. Contribution to the study of scale insects Minor Africa (1 er note). *Ann. Soc. Ento. Fran.*, 16: 175-207 [in French].
4. Balachowsky A.S., 1930. Contribution to the study of scale insects Minor Africa (9me note). Addition to the North African fauna with description of three new species. *Bull. Soc. Hist. Nat. Afr. Nord.*, 21:119-125.
5. Balachowsky A.S., 1932. Biological study of scale insects of the Western Mediterranean basin. In: Encyclopédie Entomologic XV P. Le chevalier & Fils, Paris 214p.
6. Balachowsky A.S., 1933. Contribution to the study of scale insects of North African [12me note]. Diaspines harvested in the region of Tamanrasset (Hoggar Massif) by j. Lauriol. *Bull. Soc. Hist. Nat. Afr. Nord.*, 24:253-254.

7. Balachowsky A.S., 1934. The scale insects of the central Sahara. Hoggar Mission. III. (February to May, 1928) In Seurat, L.-G, Zoological Studies Central Sahara. *Mum. Soc. Hist. Nat. Afr. Nord.*,4:145-157.
8. Balachowsky A.S & Mesnil L., 1935. Insects harmful to plants cultivated their mores, their destruction. Tome 1, Ed Busson, Paris, 627p [In French].
9. Balachowsky A.S., 1949. Study of *Rungaspidiotus* (Coccoidea- Odonaspidini) new Oran. *Bull. Soc. Hist. Nat. Afr. Nord.*, 40:107-110.
10. Balachowsky A.S., 1950. Mealybugs from France, Europe, North Africa and the Mediterranean Basin. V. Monograph Coccoidea; Diaspidinae (second part) Aspidiotini. *Entomological. News. Applicata. Industrial. Science.*,397-557.
11. Balachowsky A.S., 1953. Scale insects of France of Europe, North Africa and the Mediterranean basin. VII. Monograph Coccoidea; DiaspidinaeIV, Odonaspidini- Parlatorini.*Act. Scientif. Indust.*,1202:725-929.
12. Balachowsky A.S., 1954. Comparative study of cedar scales in Lebanon and North Africa.*Rev. Pathol. Veg. Entomol. Agric. Fr.*, 33:108-114.
13. Balachowsky A.S., 1958.Scales of the African continent Black. Aspidiotini (2nd part), Odonaspidini and Parlatorini. *Ann. Musée. Roy.Congo. Belge.* (Sciences Zoologiques), Tervuren., 4:149-356.
14. Belguendouz R & Biche M., 2015. Biodiversity of Diaspididae scale insect (Homoptera), their host plants and natural enemies in Algeria. *J. ento. Zool. Stud.*, 3: 302-309.
15. Benassy C., 1975.Citrus scales in the Mediterranean basin. *Ann. Inst. Nat. Agro. El-Harrach.*,6:118-142.
16. Ben-Dov Y., 1980. Observations on scale insects (Homoptera:Coccoidea) of the Middle East. *Bull. ent. Res.*,70: 261-271.
17. Biondi M., D'Alessandro P & Urbani F., 2015.Relationships between the geographic distribution of phytophagous insects and different types of vegetation: A case study of the flea beetle genus *Chaetocnema*(Coleoptera: Chrysomelidae) in the Afrotropical region.*Eur. J. Entomol.*,112(2): 311- 327.
18. Bonani J.P, Fereres A, Garzo E, Miranda M.P & Appezzato-Da-Gloria B., 2010. Characterization of electrical penetration graphs of the Asian citrus psyllid, *Diaphorinacitri*, in sweet orange seedlings. *Entomologia. Experimentalis. Et. Applicata.*, 134: 35 - 49.
19. Daane K.M., Almeida R.P.P., Bell V.A., Walker J.T.S., Botton M., Fallahzadeh M et al., 2012. Biology and Management of Mealybugs in Vineyards. In: Bostanian N.J, Vincent C, Isaacs R, editors. *Arthropod Management in Vineyards: Pests, Approaches, and Future Directions.* Springer Science+Business Media. 271-307.
20. De Lotto G., 1973. A new soft scale from Citrus (Homoptera: Coccoidea: Coccidae). *Bollettino. del. Laboratorio. Di Entomologia. Agraria. Portici.*, 30: 291-293.
21. Dreistadt S.H., 1996. Citricola Scale (Homoptera: Coccidae) Abundance on Chinese Hackberry and Scale Control with Spray Oil or Acephate Trunk Implants. *J. Econ. Entomol.*, 89(2): 481-487.

22. Franco J.G., Suma P., Borges da Silva E., Blumberg D & Mendel Z., 2004. Management strategies of Mealybug pest of citrus in Mediterranean countries. *Phytoparasitica.*, 32: 507-522
23. Gacemi A., Taïbi A., Medjdoub I., Medjdoub Y & Doumandji S., 2016. Citrus infestation by the black scale, *Parlatoria ziziphi* Lucas (Homoptera: Diaspididae) in Tlemcen, Algeria. *J. ent. Res.*, 40 (3): 217-221.
24. Golan K & Najda A., 2012. Differences in the sugar composition of the honeydew of polyphagous brown soft scale *Coccus hesperidum* (Hemiptera: Sternorrhyncha: Coccoidea) feeding on various host plants. *Eur. J. Entomol.*, 108: 705-709.
25. Gullan P.J.D.D & Steffan S.A., 2003. A new pest species of the mealybug genus *Ferrisia* Fullaway (Hemiptera: Pseudococcidae) from the United States. *Annals of the Entomological Society of America.*, 96: 723-737.
26. Gullan P.J & Cook L.G., 2007. Phylogeny and higher classification of the scale insects (Hemiptera: Sternorrhyncha: Coccoidea). *Zootaxa.*, 16(8): 413-425.
27. Idder-Ighili H., Idder M.A., Boughezala Hamad. M & Doumandji- Mitiche B., 2013. Relations between the white cochineal *Parlatoria blanchardi* Targiono-Tozzetti (Homoptera-Diaspididae) and some varieties of dates in Ouargla (Southeast Algeria). *Bio Resources.*, 3: 32 - 40.
28. Jendoubi H., Grissa K.L., Suma P & Russo A., 2008. Scale insect fauna (Hemiptera, Coccoidea) of citrus in Cap Bon region (Tunisia). *Bull. IOB/wprs Bulletin.*, 38: 87-93.
29. Kaneko Y, Ikeda H & Ohwaki A., 2015. Seasonal variability in the response of ground beetles (Coleoptera: Carabidae) to a forest edge in a heterogeneous agricultural landscape in Japan. *Eur. J. Entomol.*, 112(1): 135-144.
30. Kholsa S, Mendiratta G & Brahmachari V., 2006. Genomic imprinting in the mealybugs. *Cytogen. Genome. Res.*, 113: 41-52.
31. Koga R, Nikoh N, Matsuura Y, Meng X.Y & Fukatsu T., 2012. Mealybugs with distinct endosymbiotic systems living on the same host plant. Federation of European Microbiological Societies. *Microbiol. Ecol.*, 83: 93-100.
32. Koteja J., 2008. Xylococcidae and related groups (Hemiptera: Coccinea) from Baltic amber (In English; Summary in Polish). *Prace. Muzeum. Ziemi.*, 49: 19-56.
33. Koteja J & Azar D., 2008. Scale insects from Lower Cretaceous amber of Lebanon (Hemiptera: Sternorrhyncha: Coccinea). *Alavesia.*, 2: 133-167.
34. Loussert R., 1989. Citrus fruits, production. Volume 2. Technical and Documentation Lavoisier, Paris 157 p [in French].
35. Malan S.V & Niekerk A.P., 2012. Potential of South African entomopathogenic nematodes (Heterorhabditidae and Steinernematidae) for control of the citrus mealybug, *Planococcus citri* (Pseudococcidae). *J. invertebrate Patho.*, 111: 166-174.
36. Mbte P., Itoua-Apoyolo C.M., Kiyindou A., Ngokaka C., Doungou J. P., 2011. Evaluation of the damage caused to the citrus by the mealybug (*Praelongorthezia proelonga*) in the southern districts of the city of Brazzaville. *J. Appl. Bioscience.*, 39: 2619-2625.

37. Miller D.R., Miller G.L., Hodges G.S & Davidson J.A., 2005. Introduced scale insects (Hemiptera: Coccoidea) of the United States and their impact on US agriculture. *Proceedings of the entomological Society of Washington*, 107: 123-158.
38. Mohamed E.M., Basheer A.M & Abukaf N., 2012. Survey of Parasitoid Species of Citricola Scale Insect, *Coccus pseudomagnoliarum*(Kuwana) (Homoptera: Coccidae) and their Effect in Citrus Orchards at Lattakia, Syria. *Egyptian. Journal. Biological. Pest. Control.*,22(1):61-65.
39. Pacheco da Silva V.C., Bertin A., Blin A., Germain J.F., Bemardi D.,Rignol G et al., 2014. Molecular and morphological identification of mealybug species (Hemiptera : Pseudococcidae) in Brazilian vineyards. *PLoS ONE*. 9 issue7: 13.
40. Podsiadlo E & Bugila A., 2007.Morphology of the second-instar males of *Parlatoria ziziphi* (Lucas) (Hemiptera: Diaspididae). *Proceedings of the XI international symposium on scale studies*, 51- 53.
41. Rasekh A, Michaud J.P &Varandi H.B., 2011.Biology of the conifer needle scale, *Nuculaspis abietis* (Hemiptera: Diaspididae), in northern Iran and parasitism by *Aspidiotiphagus citrinus* (Hymenoptera: Aphelinidae). *Eur. J. Entomol.*,108: 79-85.
42. Ricard M., Garcin A., Jay M & Mandrin J. F., 2012. Biodiversity and regulation of pests in fruit trees, Duong-Minh Nguyen, ctifl, Paris 471p [in French].
43. Sadoudi-Ali ahmed D., Kellouche K & Sadoudi R., 2011. The cochineal of the figure tree *Ceroplastes rusci* Linnaeus (Hemiptera: Coccoidea) in a figure tree in Kabylia. *Symposium on mealybug or main pest*. Montpellier.
44. Simon E & Zyla D., 2015. New fossil taxa of Monophlebidae (Sternorrhyncha: Coccoidea) from Baltic amber. *Eur. J. Entomol.*,112(2): 381-388.
45. Stathas G.J., 2001. Ecological data on predators of *Parlatoria pergandii* on sour orange trees in Southern Greece. *Phytoparasitica.*,29: 207-214.
46. Takumasa K., Penny J.G & Douglas J.W., 2008. Coccidology. The study of scale insects (Hemiptera :Sternorrhyncha : Coccidea). *Revista. Corpoica-Ciencia. Tecnologia. Agropecuaria.*,9:55-61.
47. Tawfeek M.E., 2007. Bioecological studies on some armoured scale insects and their parasitoids. Ph.D. Thesis, Fac. of Agric. Alex. Univ, Egypt, Pp. 187pp.
48. Tawfeek M.E & Abu-shall Amany M.H., 2010. Seasonal Population Dynamics of *Parlatoria ziziphus* (Lucas) (Homoptera: Diaspididae) in Menoufia Governorate, Egypt. *Alexandria. Science. Exchange. journal.*,31(4): 331-337.
49. Tena A., Garcia-Mari F., 2008. Suitability of citricola scale *Coccus pseudomagnoliarum* (Hemiptera: Coccidae) as host of *Metaphycus helvolus* (Hymenoptera: Encyrtidae): influence of host size and encapsulation. *Biological. Control.*,46 : 341-347.
50. Trabut L., 1911. Catalogue des cochenilles observées en Algérie. *Bull. Soc. Hist. Nat. Afr. Nord.*, 3:51-64.

51. Tranfaglia A., 1974. Studi sugli Homoptera Coccoidea III. Un nuovococcino (*Coccus aegaeus* De Lotto) sugli agrumi in Italia (notizie preliminari). *Boll. Lab. Ent. agr. Filippo Silvestri*, 31:141-144.
52. Trumble J.T., Grafton-Cardwell E.E & Brewer A.J., 1995. Spatial Dispersion and Binomial Sequential Sampling for Citricola Scale (Homoptera: Coccidae) on Citrus. *J. Eco. Entomol.*, 88(4): 897-902.
54. Williams D.H & Aggarwal J.K., 1980. Computer detection and classification of three citrus infestations. *Computer graphics and image processing*, 14: 373-390.