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INVENTORY OF ORNAMENTAL PLANT MEALYBUG (HEMIPTERA PSEUDOCOCCIDAE) IN TUNISIA: SPECIES, HOST PLANTS AND DISTRIBUTION

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Mdellet L., Adouani R., Zouari S., Ben Halima M.K., Germain J.F. – Inventory of ornamental plant mealybugs (Hemiptera Pseudococcidae) in Tunisia: species, host plants and distribution.

In recent years, mealybugs (Hemiptera, Pseudococcidae) have become an important pest of ornamental plant in Tunisia due to their accident introduction and invasiveness. Awareness, early knowledge of invasive species, their host plant and geographical distribution could help to implement control methods which minimize the economic losses caused by them. A survey was conducted during 2013-2018 period to identify the mealybug species on ornamental plant, their host plant and document their geographic and periodic distribution. Seven species belonging to five genera were identified: *Maconelliococcus hirsutus* Green, *Phenacoccus peruvianus* Granara de Willink, *Phenacoccus madeirensis* Green, *Planococcus vovae* Nasonov, *Planococcus citri* Risso, *Ferrisia virgata* Cockerell and *Pseudococcus longispinus* Targioni-Tozzetti. *M. hirsutus* was the most abundant mealybug and found in twenty-one sites on *Hibiscus rosa-sinensis* and *Hibiscus mutabilis*. *P. peruvianus* was the most polyphagous specie found on five host plants belonging to four families in eleven sites. *P. citri* was the single specie observed during wet season, therefore, all the rest species were found during dry season (summer, beginning autumn). These findings provide primary baseline knowledge of the mealybug fauna on ornamental plant in Tunisia and contribute information for use in the development of sustainable ornamental pest management strategies in the country.

KEY WORDS: Mealybug, ornamental plant, invasive species, distribution, Tunisia.

INTRODUCTION

Tunisia, located on the shores of the Mediterranean, is a rich repository of various plant resources. There are 22500 species of vascular plants in the Mediterranean (MYERS *et al.*, 2000), with approximately 11700 found in the 'hotspot region' including Tunisia (THOMPSON *et al.*, 2005). Part of them were having potential worth as medicinal or ornamental plants which play roles connected with positive shade, protection, and recreation both in private and in public areas as well as to complement and decorate the urban environment (MAZZEO *et al.*, 2014). Ornamental trees, shrubs and flowers have always been extremely popular and there is large demand. Thus, the increase demand of ornamental plant and commercial exchange has provided pests which cause several damages (MAZZEO *et al.*, 2014). Indeed, a great many species of insects attack ornamental plants. Among them, aphids, scales, whiteflies, lacebugs and mealybug (YOVKOVA *et al.*, 2013; MAZZEO *et al.*, 2014; BEN-HALIMA, 2009; BEN-HALIMA *et al.*, 2014). Mealybug colonize vegetative organs and lives under bark, on leaf, inside bunches and occasionally on berries (BECERRA *et al.*, 2006). Moreover, they have been introduced into different countries in the Mediterranean Region and other areas of the Palaearctic Region (KAYDAN *et al.*, 2012). Cryptic habits and tiny size makes mealybug usually settle in small depressions or protected areas of plants which explain the fast spread throughout the Mediterranean (MARTÍNEZ-FERRER *et al.*, 2003). In Tunisia, literature

provides little information about invasive mealybugs on ornamental plants, their geographic repartition and period abundance. In order to understand which mealybugs are most likely to invade Tunisia in the future and to implement control methods which minimize their economic losses, this study aimed at showing ornamental plant invasives mealybugs species in Tunisia, their geographical distribution and determining period of their abundance.

MATERIALS AND METHODS

STUDY SITES

This work was conducted during 2013-2018 period in ten Tunisian coastal governorates (Fig. 1). A total of twenty three sites were surveyed (Table 1). Sites were chosen defined on the basis of presence of multitude varieties/species of ornamental plant and different climate.

COLLECTION OF MEALYBUGS

Infested leaves and inflorescences with mealybugs have first been photographed. Mealybugs were then collected and kept in alcohol 70° and sent to ANSES-Plant Health Laboratory/France for identification.

MORPHOLOGICAL IDENTIFICATION

Mealybugs were prepared by a five-stage process before mounting: i) the specimen was heated gently (<40°C) in 10% KOH for 20 min; ii) the specimen was washed in distilled

Fig I. Survey sites of ornamental plants mealybugs in Tunisia.

Ar: Ariana
 Be: Ben-Arous
 Bi: Bizerte
 Ga: Gabes
 Ma: Mahdia
 Mo: Monastir
 Na: Nabeul
 Sf: Sfax
 So: Sousse
 Tu: Tunis

Table 1 – Inventory sites and monitoring of ornamental plants mealybugs in Tunisia.

Governorate	Site/Zone	Climate*	Survey period
Bizerte	Bizerte City	Warm temperate	2016
Ariana	Ariana city, El-aouina, Sidi Thabet	Warm temperate	2016 - 2017
Tunis	Tunis city, El-marsa, Goulette Sidi Bou-saïd, Carthage	Warm temperate	2015 - 2017
Ben-Arous	Bou-mhel	Warm temperate	2016
Sousse	Sousse city, Msaken, Hammem-Sousse, Akouda, Chott Mariem, Kalaa Kbira, khezama, Port Kantaoui	Hot semi arid	2013 - 2018
Monastir	Monastir city	Hot semi arid	2016
Mahdia	Mahdia city	Hot semi arid	2016
Sfax	Sfax city	arid	2016
Gabes	Gabes city, Merth	Hot desert	2015 - 2016

Climate*: Koppen Geiger classification

water for 20 min; iii) the specimen was stained by incubation for 1 h in a stored solution of fuchsin in a 1:1:1 mixture of distilled water, lactic acid and glycerol; iv) the specimen was washed in glacial acetic acid for 1 h to stabilize the staining; v) the specimen was transferred to lavender oil for at least 1 h, placed in a drop of Canada balsam on a slide and covered with a cover slip. The slide was then labelled and observed immediately under a microscope or after drying (40°C for 4-6 weeks). In most cases, identification was based on the keys of COX (1989), WILLIAMS & GRANARA DE WILLINK (1992) and WILLIAMS (2004); KAYDAN & GULLAN (2012), DANZIG & GAVRILOV-ZIMIN (2014; 2015).

RESULTS

MEALYBUG SPECIES IDENTIFIED

Seven mealybug species have been identified on ornamental plant in 23 surveyed sites. These are: *Maconellicoccus hirsutus* Green (Fig. II, 1-4), *Phenacoccus peruvianus* Granara de Willink (Fig. III, 1-3), *Phenacoccus madeirensis* Green (Fig. IV, 1-3), *Planococcus vovae* Nasonov (Fig. V, 1-2), *Ferrisia virgata* Cockerell (Fig. VI), *Planococcus citri* Risso (Fig. VII) and *Pseudococcus longispinus* Targioni-Tozzetti.

HOST PLANT AND GEOGRAPHICAL DISTRIBUTION

The seven mealybugs were found on twelve ornamental plants belonging to nine families (Table 2). *Phenacoccus*

peruvianus was the most polyphagous mealybugs recorded on four host plants (*Myoporum* sp., *Citharexylum quadrangularis*, *Bougainvillea glabra*) belonging to three families (Scrophulariaceae, Verbenaceae, Nyctaginaceae). It's recorded on leaves, shoots and trunk (Fig. II, 4). *Ferrisia virgata*, *Planococcus vovae* and *Pseudococcus longispinus* were monophagous and recorded on leaves of *Lantana camara* (Verbenaceae), *Cupressus macrocarpum* (Cupressaceae) and *Jasminum grandiflorum* (Oleaceae) respectively. *Maconellicoccus hirsutus* was the most relevant mealybug recorded in 19 sites in the north, middle and south of Tunisia. *Phenacoccus peruvianus* was the second relevant species recorded in 12 sites. *Ferrisia virgata*, *P. vovae* and *P. longispinus* were the less relevant species and recorded on *L. camara*, *C. macrocarpum* and *J. grandiflorum* respectively.

MEALYBUG SPECIES AND SEASONAL ABUNDANCE

Seasonal abundance of mealybugs on ornamental plants in 23 sites was shown in Table 3. During survey period (2013-2018), all species were recorded during dry season (June, July, August). *P. citri* was the single species recorded in April (wet season). *P. peruvianus* and *M. hirsutus* were the relevant species and observed during four months (June, July, August, and September). *F. virgata*, observed on *Lantana camara*, was the single species whose period attack spreads from dry season (August, September) to wet season (October). *P. longispinus* was a less prevalent species recorded on *Jasminum grandiflorum* during short period (July) in one site/zone (Kantaoui Port).

Fig. II – *Maconellicoccus hirsutus* on *Hibiscus rosacinensis*

Fig. III – *Phenacoccus peruvianus* on *Citharexylum quadrangularis*

Fig. IV – *Phenacoccus madeirensis* on *Cestrum nocturnum*.

Fig. V – *Planococcus vovae* on *Cupressus mactocarpum*.

Fig. VI – *Ferrisia virgata* on *Lantana camara*. Fig. VII. *Planococcus citri* on *Tradescantia fluminensis*

Table 2 – Mealybug species, host plant and geographical distribution in survey sites.

Mealybug specie	Ornamental plant/ Family	Site/Governorate
<i>Maconellicoccus hirsutus</i>	<i>Hibiscus rosa-sinensis</i> /Malvaceae	– Tunis City, El-Marsa, Goulette, Sidi-Bou Saiid, Carthage/Tunis. – Port Kantaoui, Akouda, Chott Mariem, Hammem-Sousse, Msaken/Sousse. – Ariana City, El-aouina/Ariana. – Bizerte City/Bizerte. – Monastir City/Monastir. – Boumhel/Ben-Arous. – Sfax City/Sfax – Gabes City, Merth/Gabes
	<i>Hibiscus mutabilis</i> /Malvaceae	– Chott Mariem/Sousse.
<i>Phenacoccus peruvianus</i>	<i>Myoporum sp</i> / Scrophulariaceae	– Sousse City, Hammem Sousse, Akouda, Kalaa Kbira/Sousse. – Monastir City/Monastir. – Tunis City/Tunis.
	<i>Capsicum frutescens</i> /Solanaceae	– Akouda/Sousse.
	<i>Citharexylum quadrangularis</i> /Verbenaceae	– Akouda/Souss
	<i>Bougainvillea glabra</i> /Nyctaginaceae	– Sousse City, Akouda, Hammem-Sousse, Msaken, Kantaoui-Port/Sousse. – Ariana City, El Aouina/Ariana. – Tunis City, El-Marsa/Tunis. – Monastir City/Monastir.
<i>Phenacoccus madeirensis</i>	<i>Cestrum nocturnum</i> /Solanaceae	– Akouda/Sousse.
	<i>Lantana camara</i> /Verbenaceae	– Hammem-Sousse/Sousse.
<i>Ferrisia virgata</i>	<i>Lantana camara</i> /Verbenaceae	– Khezama/Sousse.
<i>Planococcus vovae</i>	<i>Cupressus macrocarpa</i> /Cupressaceae	– Hammem-Sousse/Sousse.
<i>Pseudococcus longispinus</i>	<i>Jasminum grandiflorum</i> /Oleaceae	– Kantaoui-Port/Sousse.
<i>Planococcus citri</i>	<i>Tradescantia fluminensis</i> /Commelinaceae	– Sidi Thabet/Ariana.
	<i>Thecoma smithi</i> /Bignoniaceae	– Chott Mareim/Sousse.

DISCUSSION

The survey carried out in 23 sites/zones of 10 Tunisian coastal governorates allowed the discovery of seven mealybugs' species on 12 ornamental plants. These include *M. hirsutus*, *P. peruvianus*, *P. madeirensis*, *P. vovae* and *F. virgata*, *P. citri* and *P. longispinus*. So, this study reports for the first time on the existence of *M. hirsutus*, *P. peruvianus*, *P. madeirensis*, *P. vovae* and *F. virgata* in Tunisia and in the North of Africa (BEN-HALIMA *et al.*, 2014; 2015). *M.*

hirsutus probably from South-East Asia and has spread to Australia, Africa, the Middle East, Central America, the northern countries of South America with a recent report from Brazil (MARSARO JÚNIOR *et al.*, 2013), and USA (EPPO, 2006; BOGRÁN & LUDWIG, 2007; CHONG, 2009). In Europe, *M. hirsutus* was recorded only in Cyprus (EPPO, 2011). Recently, SPODEK *et al.* (2016) reported the *M. hirsutus* in Israel. *P. peruvianus* recorded in *Bougainvillea glabra*, *Myoporum sp.*, *Citharexylum quadrangularis* and *Capsicum frutescens* has a Neotropical origin and has been

Table 3 – Abundance of mealybugs according to the season.

Mealybugs	Wet season				Dry season					Wet season		
	January	February	March	April	May	June	July	August	September	October	November	December
<i>Planococcus citri</i>				+			+	+				
<i>Planococcus vovae</i>							+					
<i>Pseudococcus longispinus</i>							+					
<i>Ferrisia virgata</i>								+	+			
<i>Phenacoccus madeirensis</i>								+	+			
<i>Phenacoccus peruvianus</i>						+	+	+	+			
<i>Maconellicoccus hirsutus</i>						+	+	+	+			

recently recorded in Europe (GRANARA DE WILLINK & SZUMIK, 2007). It was reported in southern Spain in 1999, subsequently, Sicily in 2002, U.K. and Corsica in 2005, Portugal in 2006, France mainland in 2008, Majorca Island in 2010 and Greece in 2013 (BELTRÀ *et al.*, 2010; VASILIKI & PANAGIOTIS, 2013). *P. madeirensis* recorded in two sites on *Cestrum nocturnum* and *Lantana camara* was considered from Neotropical origin and now was widely distributed in Afrotropical, Australasian, Nearctic, Neotropical and Oriental zoogeographical regions (BEN-DOV *et al.*, 2013). In Europe, *P. madeirensis* was recorded in 1990 in Italy (MAROTTA & TRANFAGLIA, 1990), Crete (JANSEN *et al.*, 2010), France (MATILE-FERRERO & GERMAIN, 2004), Greece (PAPADOPOULOU & CHRYSOHOIDES, 2012), Portugal (FRANCO *et al.*, 2011), Spain (BELTRÀ & SOTO, 2011) and Turkey (KAYDAN *et al.*, 2012). There are also several records in the Far-East of the Palearctic Region (KONDO *et al.*, 2001). In the last decade, the Madeira mealybug has continued to spread in the Mediterranean region and in other parts of the world, such as southern Asia and tropical Africa (WILLIAMS, 2004). As for host plant, *M. hirsutus* was relevant on leaves, shoots, trunk and collar of *H. rosasinensis* and seldom on *H. mutabilis*. BEN-DOV *et al.* (2015) reports the polyphagy of *M. hirsutus* which feeds on a wide range of ornamental and agricultural host plant species distributed in 218 genera of 76 botanic families. Fabaceae, Malvaceae and Moraceae were the preference host plants and economical damages was on avocado, banana, citrus, cotton, grapevine and mulberry (EPP0, 2005; 2006). *P. peruvianus* was recorded on four ornamental plants belonging to four families. *Bougainvillea* and *Myoporum* were the most attacked plants. BELTRÀ *et al.* (2010) shows that *P. peruvianus* has been reported on Acanthaceae, Amaranthaceae, Asclepiadaceae, Asteraceae, Aucubaceae, Myoporaceae, Scrophulariaceae and Solanaceae. *Phenacoccus madeirensis*, *Ferrisia virgata*, *Planococcus vovae*, *Pseudococcus longispinus* and *Planococcus citri* were less relevant and monophagous recorded in limited sites. *F. virgata* was reported on cotton in India, Pakistan and Brazil (OLEIVEIRA *et al.*, 2014). *P. citri* is a serious polyphagous species infesting a broad range of subtropical fruit plants and ornamentals worldwide (MANSOUR *et al.*, 2017). In Tunisia, *P. citri* was the most abundant and frequent scale insect species occurring on citrus trees (JENDOUBI, 2007). As for abundant populations of recorded species, it was alternately depending on the season and the relevant population was during dry season. Indeed, influence of

weather and ecosystems were among factors which affect mealybugs abundance and geographical repartition (CORREA *et al.*, 2015). The climate as an extrinsic integrative factor plays a crucial role in determining the abundance and distribution of insect pest population. SINGH *et al.* (2009) had observed that abiotic factors are believed to be responsible for pest population dynamics. NÉBIÉ *et al.* (2016) show the abundance of *F. virgata* during dry period and there are a significant and negative correlation between the populations of *F. virgata* with relative humidity and rainfall. Also, KATKE (2008) shows the incidence of *F. virgata* during dry season or prolonged period of drought. Therefore, GHOSE (1972) was of the opinion that *M. hirsutus* was active during winter also, without hibernation but was most active during March-October on roselle around West Bengal. AZAM (1983) found that the active period of *M. hirsutus* was during June-August and October-March on grapes around Hyderabad. These results demonstrate the necessity of several researches on impact of ecosystems and climate on abundance, distribution, biological parameters and abundance of their natural enemies in order to implement control methods which minimize their economic losses. In conclusion, during this study, seven mealybugs species were inventoried on ornamental plants in 23 sites. These include *M. hirsutus*, *P. peruvianus*, *P. madeirensis*, *P. vovae*, *F. virgata*, *P. citri* and *P. longispinus*. *M. hirsutus* and *P. peruvianus* were more abundant than *P. madeirensis*, *P. vovae*, *F. virgata*, *P. citri* and *P. longispinus* and their periodicity were related to geographic ornamental plant distribution and climate characteristic. Abundance of *M. hirsutus* and *P. peruvianus* may cause significant damages to ornamental plant. This shows the need to explore opportunities for sustainable control of this pest. The management of these mealybugs needs additional research on their host plants, damages, dispersion and their natural enemies.

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