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**PALM SPECIES POTENTIALLY RESISTANT TO RED PALM WEEVIL ATTACKS IN SITES
OF EASTERN SICILY HEAVILY INFESTED**

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SUMMARY

During the period of July 2006 - August 2012 an official survey for detection of Red Palm Weevil (RPW) was carried out by the Plant Protection Organization (Servizio Fitosanitario Regionale) in Sicily. With regard to the Eastern Coast we report the percentage of the different species of palm trees infested compared to the overall quantity of infested plants. The data collected show the great prevalence of the species *Phoenix canariensis*. These results are validated comparing the composition of plants, belonging to the family of Arecaceae, recorded in representative sites of public and private green in the period between 2006-07, at the beginning of the infestation, and the present composition. According to surveys conducted in sites severely and historically infested, with a relevant presence of *P. canariensis* in the urban green, we point out a significant "resistance" for certain species officially reported as potentially sensible to RPW.

Key words : *Rhynchophorus ferrugineus*, *Phoenix canariensis*, official survey, Arecaceae, green areas.

RÉSUMÉ

ESPÈCES DE PALMIERS POTENTIELLEMENT RÉSISTANTES AUX ATTAQUES DU CHARANÇON ROUGE SUR DES SITES DE SICILE ORIENTALE FORTEMENT INFESTÉS

Durant la période de Juillet 2006 à Août 2012, un sondage officiel a été réalisé par le service de la protection des végétaux (Servizio Fitosanitario Regionale) en Sicile pour relever la présence du charançon rouge des palmiers (CRP). En ce qui concerne la côte orientale de l'île, nous présentons le pourcentage des différentes espèces touchées parmi les palmiers infestés. Les données recueillies montrent que la prévalence de l'espèce *Phoenix canariensis*. Ces résultats sont validés en comparant la composition des arbres, de la famille des Arecaceae, enregistrée dans des sites représentatifs des espaces verts publics et privés en 2006-07, au début de l'infestation, à la composition actuelle. Selon des enquêtes menées dans les sites gravement et longuement infestés, avec une présence pertinente du *P. canariensis* dans un milieu urbain, on met en évidence une importante «résistance» de certaines espèces, officiellement déclarées comme étant potentiellement sensible au CRP.

Mots-clés: *Rhynchophorus ferrugineus*, *Phoenix canariensis*, enquête officielle, Arecaceae, espaces verts.

INTRODUCTION

In Italy, *Rhynchophorus ferrugineus* was first detected in October 2004 in a palm nursery near Pistoia (Tuscany) (Sacchetti *et al.*, 2006). In the following year, the Red Palm Weevil (RPW) spread to other regions in southern and central Italy including Sicily, where it was detected mainly on old *Phoenix canariensis* palms growing along the eastern coast of the island (Conti *et al.*, 2005, Longo & Tamburino, 2005; Longo, 2006). The European Community, with the last decision n. 2010/467 CE, established emergency measures and listed the following sensible species (with a diameter larger than 5 cm at the base of the stipe). The plant names are corrected according to the World Checklists of selected plant families of Kew Royal Botanic Gardens (<http://apps.kew.org/wcsp/home.do>): *Areca catechu*, *Arecastrum romanzoffianum* (= *Syagrus romanzoffiana*), *Arenga pinnata*, *Borassus flabellifer*, *Brahea armata*, *Butia capitata*, *Calamus merrillii*, *Caryota maxima*, *Caryota cumingii*, *Chamaerops humilis*, *Jubaea chilensis*, *Livistona australis*, *Livistona decipiens* (= *Livistona decora*), *Metroxylon sagu*, *Cocos nucifera*, *Corypha gembanga* (= *Corypha utan*), *Corypha elata* (= *Corypha utan*), *Elaeis guineensis*, *Howea forsteriana*, *Oreodoxa regia* (= *Roystonea regia*), *Phoenix canariensis*, *P. dactylifera*, *P. theophrasti*, *P. sylvestris*, *Sabal umbraculifera* (= *Sabal palmetto*), *Trachycarpus fortunei* e *Washingtonia spp.* In 2011, in Italy according to an official survey, are reported around 4300 sites with outbreaks regarding the following species: *B. armata*, *C. humilis*, *T. fortunei*, *P. canariensis*, *P. dactylifera*, *P. sylvestris*, *Washingtonia spp.* In the period 2006 - 2011 in Sicily around 20,000 palms, prevalently *P. canariensis*, were infested by RPW and 16,000 were cut and destroyed in the context of a specific programme of the Sicilian Region applied by the Forestry Department (ARFD). The wide diffusion of the infestation in public and private green areas and the difficulty in the application of the eradication programme did not permit to reach the result to control and eradicate the parasite. In addition, the high cost and the complexity of the operations of cutting and destruction as well as the discontinuous availability of chemicals compounds for the pest control, has contributed to the low success of the programme. The data regarding the susceptible species reported by the European documents do not give any information about the level of susceptibility of the different species of palms. In Spain the effects of antixenotic or antibiotic mechanisms of resistance against this pest for *W. filifera* and *C. humilis*, have been demonstrated in semi-field trials, however, the host status of the two species remains unclear (Dembilio *et al.*, 2009). The present work after 8 years from the beginning of the infestation focuses for Eastern Sicily on the composition of the palm trees attacked and destroyed in the period between 2006-2012, following the records submitted by private owners and by authorities to the "Servizio Fitosanitario Regionale" of Sicily. Furthermore, a specific survey was carried out in the same period, in representative green sites, comparing the palms' consistency between 2006 and today, in order to know the level of susceptibility to the pest of the controlled Arecaceae species.

MATERIAL AND METHODS

HISTORICAL GARDEN IN SICILY

The presence of palms in 140 historical and traditional gardens located in Sicily has been recognized through bibliographic surveys (Bazan *et al.*, 2005; Chirco *et al.*, 2002; Guglielmo *et al.*, 2001; Guglielmo *et al.*, 2006; Mazzola *et al.*, 2006; Pavone & Salmeri, 1994; Salmeri *et al.*, 2007) and field investigations. According to Italian law (n. 1089 of 1939), a garden is considered 'historical' if it is at least 50 years old. Various reports are analysed. The palm names are uniformed to indication of to the World Checklists of selected plant families.

COMPULSORY MEASURES

Our observation concerned the data collected during the official survey of *R. ferrugineus*. The first data used originate from a number of records of Eastern Sicily municipalities, each of which had infested palm trees, between the years 2006 and 2012. The total number of infested plants of the Aracaceae family reported was collected prevalently in the provinces of Catania e Ragusa rather than in Messina, Siracusa, Enna. The data refers to application of compulsory measures for cutting and destroying the infested trees adopted with the public regional funds. The citizens were interested in communicating the infested palm trees in order to receive the public service. The collected records concerned location, number, species and height of infested trees. The compulsory measures, consisting in the cutting of the infested plant and its destruction, were managed, via bio-grinding by Forestry Department). Thermic treatment was also adopted by private and public owners since 2010 when no fund were provided. The percentage of each palms species infested related total number of infested trees was reported.

SURVEY ON REPRESENTATIVE SITES

The second data set, regarding the same period, concerned the assessment of public and private gardens and other sites selected for the large variety of palm species hosted (23 sites), comparing the number of the trees of palms, for each species, present at the beginning and at the end of the study period. These sites were strongly infested by *R. ferrugineus* with high number of dead palms, in particular *P. canariensis*. The species monitored for the susceptibility to infestation of RPW were the most widespread in our municipalities. To determine the percentage of dead trees the weighted average was adopted. The specimens of *C. humilis* were reported as groups and not as individual trees. Rarely, in the observed period, the trees were treated, excepted for the time of the initial infestation during 2006/07, or sometimes in private gardens. Lack of available authorized compounds, ecological concerns, high cost of the continuous applications (around monthly) are all reasons for the limited reliance to the chemical approach. The density of RPW population in the study period was monitored with the help of pheromone traps. Rhynchotrap.

RESULTS

HISTORICAL GARDEN IN SICILY

All information, obtained in several years, is given before the RPW infestation and for this reason it is useful to describe the traditional presence of palm trees in Sicily. The species listed are 37 belonging to 16 genera. To point out how in just 3 gardens were not observed the presence of any representative of the family as a proof of the palms are in fact a connotative element of the space ornamental. The average number of species present in single garden is 4.8; in the garden of Villa Malfitano Whitaker in Palermo having as many as 19 different species. Among the species represented is of absolute importance *Phoenix canariensis*, surveyed more than 87.0% of the plants to green, followed by endemic *Chamaerops humilis* (55.7%), *Washingtonia filifera* (48.6%), *W. robusta* (47.9%) and *P. dactylifera* (39.3%) (Table I).

Table I: Percent occurrence of major palm species in the reviewed (according to cited literature) historical gardens of Sicily (140 sites).

Pourcentage de présence des principales espèces de palmiers dans les jardins historiques de Sicile examinés (selon citer la littérature) (140 sites).

Species	% TOT
<i>Brahea armata</i> S. Watson	19
<i>Butia capitata</i> (Mart.) Becc.	9
<i>Chamaerops humilis</i> L.	56
<i>Howea forsteriana</i> (F. Muell. ex H. Wendl.) Becc.	21
<i>Livistona australis</i> (R. Br.) Mart.	9
<i>Livistona chinensis</i> (Jacq.) R. Br. ex Mart.	29
<i>Phoenix canariensis</i> hort. ex Chabaud	87
<i>Phoenix dactylifera</i> L.	39
<i>Phoenix reclinata</i> Jacq.	12
<i>Sabal palmetto</i> (Walter) Lodd. ex Schult. & Schult. f.	9
<i>Syagrus romanzoffiana</i> (Cham.) Glassman	12
<i>Trachycarpus fortunei</i> (Hook.) H. Wendl.	37
<i>Washingtonia filifera</i> (Linden ex André) H. Wendl.	49
<i>Washingtonia robusta</i> H. Wendl.	48

COMPULSORY MEASURES

Out of 7296 affected trees (Table II) subjected to control measures, according to official reports, about 99% was related to the *P.canariensis* species. The species *Washingtonia filifera* and *W. robusta* were interested for the 0.5%. The reports of infected trees of *P dactylifera*, *C. humilis*, *S. romanzoffiana* were irrelevant (0.03- 0.05%), although they are species widely diffused in the landscape and in the historical gardens (Table I). On the contrary, the individuals infected of the exotic species *Sabal* and *Jubaea* were irrelevant in percentage, but probably are highly susceptible in relation to their rare presence in the green sites.

Table II: Total number of palm trees felled in the period 2006-2012 in Eastern Sicily.

Nombre total de palmiers abattus pendant la période 2006 - 2012 dans l'est de la Sicile.

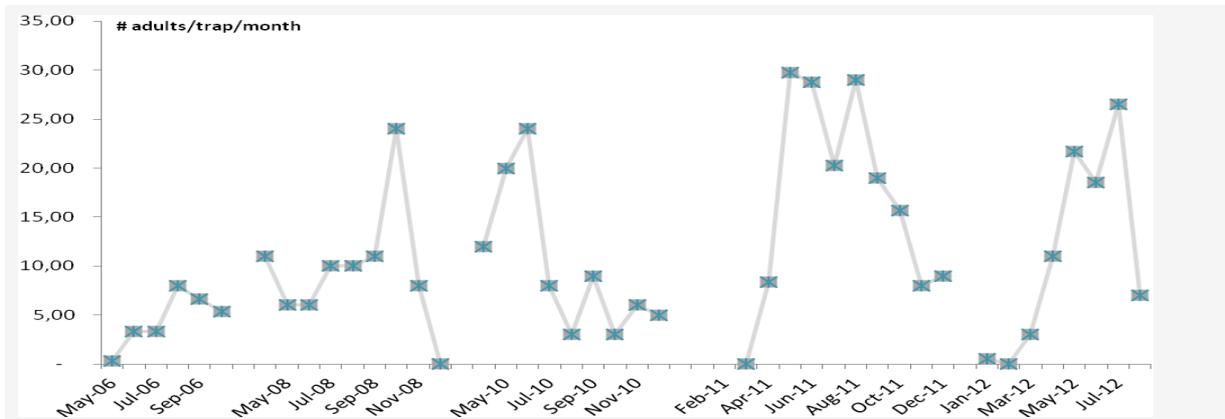
Species	number	%
<i>Phoenix canariensis</i>	7248	99.34
<i>Washingtonia</i> spp.	36	0.49
<i>Chamaerops humilis</i>	4	0.05
<i>Phoenix dactylifera</i>	4	0.05
<i>Syagrus romanzoffiana</i>	2	0.03
<i>Sabal</i> spp.	1	0.01
<i>Jubaea chilensis</i>	1	0.01
TOTAL	7296	100.00

SURVEY IN REPRESENTATIVE SITES

In the 23 sites involved in the study, at the beginning of the survey in 2006, 1576 specimen belonging to 16 different species were recorded. In the study period the population density of RPW, as assumed by captures in pheromone traps, increased after the first year of monitoring and was comparable in the other years (Figure 1).

Figure 1: RPW captures in pheromone traps during 2006-2012 in eastern Sicily.

Charançon rouge capturés par les pièges à phéromone entre 2006 et 2012 en Sicile orientale.



With regard to the initial number of individuals of palm trees, due to the attacks of RPW, a sensible modification in the percentage composition of the species was observed during the study period, showing their different degree of mortality (Table III).

Table III: Mortality of different palms species due to RPW between 2006 and 2012 in eastern Sicily (23 representative sites).

Mortalité des différentes espèces des palmiers à causée par le Charançon rouge en Sicile orientale entre 2006 et 2012 (23 sites représentatifs).

PALM SPECIES	Total 2006	Total 2012	% mortality	Std. Dev.
<i>Phoenix canariensis</i>	526	57*	89.16	13.71
<i>Phoenix dactylifera</i>	62	58	6.45	4.57
<i>Washingtonia robusta</i> **	148	146	1.35	3.87
<i>Washingtonia filifera</i>	191	183	4.19	19.81
<i>Trachycarpus fortunei</i>	100	100	0	-
<i>Butia capitata</i>	44	43	2,27	1,17
<i>Brahea armata</i>	69	63	8.70	24.12
<i>Brahea edulis</i>	2	2	0	-
<i>Chamaerops humilis</i>	183	183	0	-
<i>Syagrus romanzoffiana</i>	80	80	0	-
<i>Howea forsteriana</i>	94	89	5.32	2.80
<i>Sabal spp.</i>	7	5	28.57	58.93
<i>Livistona chinensis</i>	36	36	0	-
<i>Phoenix robellinii</i>	3	3	0	-
<i>Phoenix reclinata</i>	10	10	0	-
TOTAL	1576	1080	31.41	-

the specimens prevalently showed features of both species (*P. canariensis* and *P. dactylifera*)**rare infested specimens observed in area not under investigation.

P. canariensis, as expected, was strongly affected with reduction around 90%. The level of reduction was homogenous among the sites inspected as confirmed by the Standard Deviation. In some sites *P.canariensis* was completely displaced; in other sites the survival of specimens, with some phenotypical features different to *P. canariensis* (in some cases intermediate with *P. dactylifera*) was recorded.

The species *B. armata*, recorded in 12 sites, showed a reduction of around 9%, but the data are not uniform in the different sites surveyed. *P. dactylifera* resulted susceptible with the level of 7% with uniform data from the different sites. Follow *W. filifera* with a 4% of reduction

concerning old trees, but data are not uniform in the surveyed sites. *W. robusta* showed a very low loss. *Sabal* spp was highly affected (29%), nevertheless the value was aleatory since this species was detected in only two sites. *H. forsteriana* has shown a reduction of 5%. The S.D. is low because the dead specimens were part of a unique, ancient and specific site.

DISCUSSION

The species listed in historical gardens are few in relation to the wide number of Arecaceae (Dransfield *et al.*, 2008) and the potentiality of Italy. This country, in fact, is among the European countries where the greatest number of species is to be found in cultivation. In total over 100 species belonging to 51 genera have been identified (Noto & Romano, 1987). Palms are undoubtedly useful in landscaping the urban environment and urban roadways. The main elements that account for their usefulness are their noteworthy ornamental effect, their adaptability to specific adverse conditions often linked to the proximity to the sea, and their capacity to grow regularly without demanding special attention (Broschat & Meerow, 2000). The palm trees, to their former use, were extremely widespread in the historic gardens of Sicily (Barbera & Romano, 2009) and represent a characteristic feature. The surveyed area suffered an intensive infestation of RPW, along the study period, with preference since the beginning (2005) for *P. canariensis* (Conti *et al.*, 2008). Hence the historical heritage of Canary palm, which has represented the major ornamental species in the private and public sites of Sicily, is being dramatically compromised. At the beginning of the survey (2006) in the 23 sites monitored, the species *P. canariensis* was present with 33% of incidence out of the total number of individuals recorded, (not reported in the tables of results) followed by *W. filifera* and *W. robusta*, respectively with 12 and 10%; *C. humilis* with 11%. The trees of these species, for their dimension, represent the prevalent features of the sites. The incidence of *P. canariensis* in 2012 was reduced to 5.3%, determining a change in the features of the green areas, with a relative increase of the proportion of other palm species. Many of the specimens until now present in the area frequently showed intermediate morphological characteristics between *P. canariensis* and *P. dactylifera*. The distinction of these species is often based solely on morphological traits, and it would be easily accomplished if the differences among individuals of both species were as obvious as described by different authors (González-Pérez *et al.*, 2004). It is also possible to frequently find adult specimens that share features of both species. Hybridisation between *P. dactylifera* and *P. canariensis* in nature has been hypothesised by different authors (Kunkel & Kunkel, 1974; Hodel, 1995; Barrow, 1998; Morici, 1998; Sosa *et al.*, 1998). In this frame individuating a DNA marker able to recognize the hybrids of the two species is very interesting. The species *P. dactylifera* was less affected and the infestation occurred with a different progress, compromising the internal tissue of the stipe with rare external evidence of infestation (production of exudates). In some cases the trees have suddenly collapsed. During the official survey it was observed that rarely the old trees of this species were compromised by RPW infestation differently from some cases of adult individuals, recently (last decade) imported. The rare specimens of *P. reclinata*, with a typical growth in groups of great aesthetical impact, were not affected by the noxious organism. *W. filifera* was more affected compared to the co-genus *W. robusta*, differently to what observed by other authors (Dembilio *et al.*, 2004). The reasons of this different level of infestation are to be investigated. The data regarding to *W. robusta* are reliable because the species is widely present in the study sites. In *Washingtonia* spp., the evidence of the presence of the insect is located in different parts of the stipe, rather than in the apical portion of the crown, as normally occurs for *P. canariensis*. The data of *C. humilis* and *T. fortunei*, species widely diffused in the sites, have confirmed their relevant resistance to the pest. With regard to the first species it was suggested that a mechanism of antixenosis is involved in this resistance (Dembilio *et al.*, 2004). Rarely infestations of *Paysandisia archon* have been detected on these species. *Brahea armata* and *Sabal* ssp. were species highly susceptible to the infestations with the difference that the first

species is frequent in the examined sites, while the second is very rare. The same susceptibility was observed for *B. edulis*, rarely present. *Butia capitata* was moderately susceptible, even though only few specimens have been recorded. The data on *Howea forsteriana* are partial because the dead specimens were part of a unique ancient and specific site. All other investigated species demonstrated in the study period to be resistant to the infestations.

CONCLUSION

The attack of the Red Palm Weevil has certainly affected the presence of palm trees in Sicily. Surely *Phoenix canariensis* is the species most strongly affected, although we cannot exclude that other species, which are less abundant and/or less widely distributed in the green areas, are very susceptible. The observations so far unfortunately based only on morphological characteristics, would seem to confirm that some specimens, probably hybrids between *P. canariensis* and *P. dactylifera*, are able to survive even in sites where the presence of the RPW is very high. In this context particular interest could take the genetic characterization of these individuals which may be able to survive in areas heavily infested. The problem of rehabilitation of green spaces and landscape contexts, in which the palms in the past were one of the most distinctive features, remains. Their substitution appears difficult both from the aesthetic and functional point of view. Palm species more tolerant to the RPW could be a solution. The need to continually monitor the population of *Rhynchophorus ferrugineus* and to immediately identify infestation of individuals of palm species previously little affected remains important.

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