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Exotic Scale Insects (Coccoidea) on Ornamental Plants in Italy: a Never-Ending Story

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Abstract: The introduction of ornamental plants into Italy for commercial and hobby purposes has provided scale insects with many chances of dispersion. Coccoidea often go unnoticed at border controls due to their cryptic lifestyle. Moreover, many of the introduced alien species become acclimatized outdoors, possibly due to the effects of urban pollution and global warming. The authors attempt to analyse this phenomenon and report on the records of new alien species in Italy, starting from the end of the Second World War. In the period 1945-1995, an average of 0.64 new introduced alien species were reported per year, whereas an average of 0.7/year were introduced between 1995 and 2005 and 1.25/year since 2005. About fifty alien species have been recorded so far in Italy, of which about 50% are presently acclimatized on ornamentals. The increase in alien species introduction is probably due to: the ever easier and faster transport and dispatch of plants in a globalized world trade; the free movement of goods within the European Union; and the weakness of the National Plant Protection Organization (NPPO) monitoring. Moreover the effect of global warming may have played an important role, directly enhancing the survival and development of the insects in their new environment. The authors comment and discuss the more invasive species, namely *Ceroplastes japonicus* Green, *C. ceriferus* Fabricius, *Protopulvinaria pyriformis* (Cockerell), *Phenacoccus madeirensis* Green, *Phenacoccus peruvianus* Granara de Willink, *Phenacoccus defectus* Ferris, *Chrysomphalus aonidum* L. and *Aulacaspis tubercularis* Newstead.

Key words: Alien species, Hemiptera Coccoidea, ornamental plants

Introduction

The introduction of ornamental plants into Italy is so frequent and common that their total value was about €470 billion during the last year (2012) (Censori, Rossetto 2013). Ornamental plants play roles connected with positive sensations and therefore they are chosen to provide shade, protection and recreation, both in private and in public areas, as well as to complement and decorate the urban environment. Commercial exchanges have provided scale insects with an effective route of dispersion. Coccoidea often go unnoticed at border control centres due to their morphology, biology and behaviour, being mainly concealed on hidden parts of their host plants.

The exchange of succulent plants (or parts of plant) by hobbyists is also quite common; these plant movements escape any control by Quarantine Services and contribute greatly to the dispersion of scale insects, particularly on Cactaceae (i.e.

Hypogeococcus pungens Williams & Granara de Willink) both between and within countries (Pellizzari, Germain 2010b).

Once introduced into a new environment, alien species may become acclimatized, surviving outdoors. Many factors influence their settlement: climate, the presence of host plants, the absence of specific natural enemies, their reproductive strategies (Jucker, Lupi 2011), urban warming (Meineke *et al*. 2013), and air pollution (Pitan 2008). Also, global warming probably plays an important role in acclimatization, changing both the climatic conditions and the phenology of the host plants and, thus, offering better opportunities for the settlement and the survival of species introduced from warmer tropical and sub-tropical areas.

Italy is a nodal point for commerce and tourism as it is placed in the centre of the Mediterranean basin. This fact exposes the country to greater risks of having alien species introduced. This can be inferred by the fact that many first reports of alien insects in Europe have occurred in Italy (Jucker, Lupi 2011).

Here we report on our studies of this phenomenon since the end of the Second World War to the present, a period in which there have been of major increases in trade exchanges and tourism, providing the scale insects with many opportunities to invade new environments.

Pest insects introduction

There has been an increasing number of alien insects arriving in Italy since the middle of the last century; a lot of them are Hemiptera (57.7%), of which 97% are Sternorrhyncha, which have been introduced mainly through the movements of ornamental plants (Jucker, Lupi 2011).

A first attempt to analyse this invasion of alien insects into Italy was conducted by Tremblay (1988), who published a list of alien insects introduced between 1960 and 1985. His list included more than 40 species, of which 75% were Sternorrhyncha, mainly mealybugs. In particular, among the 20 mealybug species, 11 had been recorded on ornamental plants.

In 1997, other authors (Pellizzari, Dalla Montà 1997) analysed the same phenomenon over a longer period, from 1945 to 1995, in order to have enough data to correlate the increase in the frequency and speed of transportation with the rate of introduction of new species. According to these data, in the years from 1945 to 1995, 32 species of scale insects had been introduced, of which 50% were Pseudococcidae (including *Rhizoecus* Kunckel d'Herculais and *Ripersiella* Tinsley, subsequently separated into the family Rhizoecidae (Hodgson, 2012), 28% Diaspididae, 9% Coccidae, 6% Eriococcidae and 3% Halimococcidae and Phoenicococcidae. In 2005, a further increase in the number of species was noted in the paper of Pellizzari *et al*. (2005), which brought the number of introduced species to 38. More recently, still further reports (Pellizzari 2005, Pellizzari, Danzig 2007, Beltrà *et al*., 2010; Pellizzari, Germain 2010a; Pellizzari, Kozàr 2011, Pellizzari, Porcelli 2013) have increased the list to 49 species, of which about 50% are presently acclimatized (Table 1, Fig. 1).

In the period 1945-1995, an average of 0.64 new introduced alien scale insects were reported per year, whilst an average of 0.7/year were found between 1995 and 2005 and this has now risen to 1.25/year since 2005.

The trend for increasing scale insect introductions shows a more than proportional increase due to the ever faster intercontinental transport of ornamentals on a global scale. Moreover, plants can move freely within the European Countries without any specific control and, in their new country, climatic changes enhance the pest opportunities to survive. Global warming and mild winters also indirectly affect acclimatization frequencies by increasing the abundance of suitable host plants for introduced scale insect species.

Information on the most common invasive scale species in Italy is reported below.

Invasive species

Family Coccidae

***Ceroplastes japonicus* Green, 1921** and ***C. ceriferus* (Fabricius, 1798)**

The Japanese wax scale represents a serious phytosanitary threat mainly to laurel, holly and ivy. It tends to aggregate in mixed demes with other pests (i.e. *Aonidia lauri* (Bouché), *Coccus hesperidum* L.) on laurel, mainly in North Italy, where it is often associated with *C. ceriferus* (Fabricius). The last species has been recorded in North Italy since 2001 (Mori *et al.* 2002) and it is less aggressive than the former.

C. japonicus is widespread on ornamentals in several European countries, both outdoors (i.e.

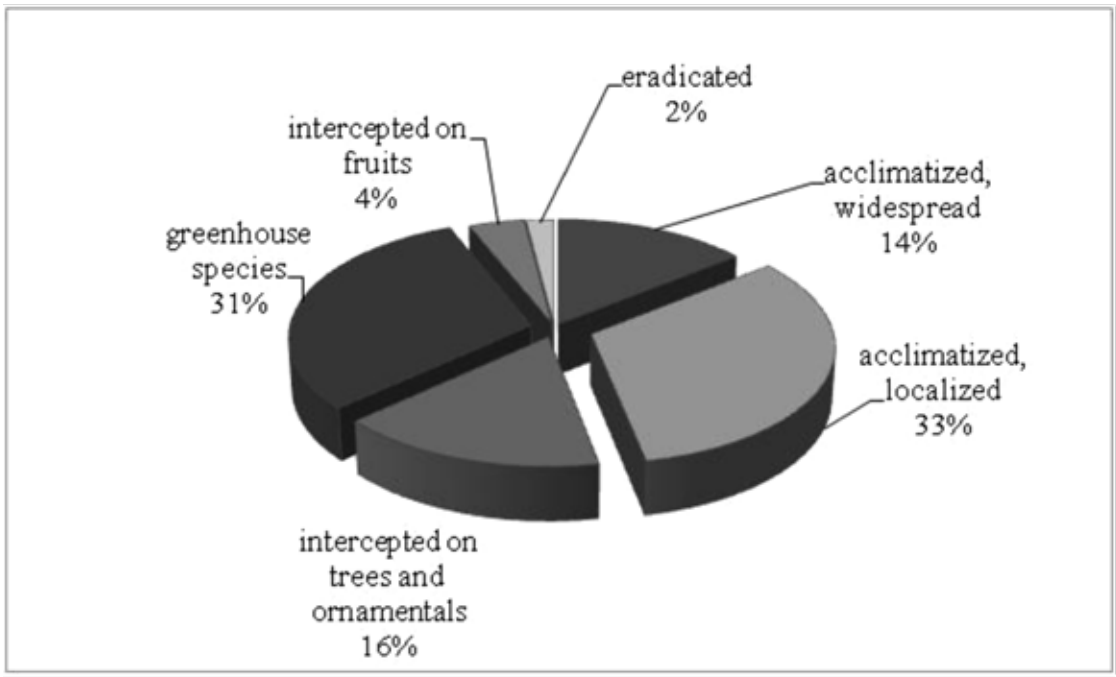

Fig. 1. Fate of scale insects species introduced in Italy between 1945 and 2013

France, Slovenia, Croatia, Bulgaria) and indoors (i.e. Hungary, UK) (Fetykò, Kozár 2012), whereas *C. ceriferus* is so far restricted to North Italy.

***Protopulvinaria pyriformis* (Cockerell, 1894)**

The pyriform scale is a Neotropical and polyphagous species and is considered a serious pest of fruit trees and ornamentals, including *Laurus*, *Schefflera*, *Hedera*, *Gardenia, Camellia, Pittosporum* and *Fatsia*. In the Mediterranean basin, it is recorded in Portugal (Franco *et al.* 2011), Spain (Beltrà *et al.* 2011), France (Canard 1996), Greece (Stathas *et al.* 2009), Israel (Blumberg, Blumberg 1991) and Italy where it has been reported from several regions since 1993 (Longo *et al*. 1995, Pellizzari 2003). In 2010, a heavy infestation was found in lemon orchards in Sicily (Suma, Cocuzza 2010). The damage is related to sap removal and excretion of abundant honeydew with consequent sooty mould blackening.

Family Pseudococcidae

***Phenacoccus madeirensis* Green, 1923**

The Madeira mealybug, a polyphagous and cosmopolitan species, was recorded in Europe (Madeira Islands) in 1923 (Pellizzari, Germain 2010b). In Italy, it has been recorded since 1981 (Tranfaglia 1981, as *Ph. gossypii* Townsend & Cockerell) and has now spread to several other regions (Longo *et al*. 1995; Mazzeo *et al*. 2008). It infests many ornamentals and agricultural crops (including *Lantana*, *Pelargonium*, various cacti and Solanaceae) and causes defoliation and dieback.

Recently, the presence of numerous natural enemies, such as Coccinellidae (i.e. *Cryptolaemus montrouzieri* Mulsant) and encyrtid parasitoids has significantly reduced its populations.

***Phenacoccus peruvianus* Granara de Willink, 2007**

The Bougainvillaea mealybug was recorded in Europe for the first time in 1999 in Spain (Almeria) and later in 2002 in Italy (Sicily) (Beltrà *et al*. 2010). *P. peruvianus* is a polyphagous species but feeds mainly on plants of the genus *Bougainvillea*, which is widely cultivated in gardens of the Mediterranean region and is frequently traded as a potted plant. In Sicily, the species is currently acclimatized and generalist natural enemies reduce the outbreaks that occur every spring. In Spain, an effective parasitoid was fortuitously detected recently belonging to the genus *Acerophagus* (Encyrtidae) (Beltrà *et al*. 2013).

***Phenacoccus defectus* Ferris, 1950**

This North American species has been recorded several times since 2009 on potted Crassulaceae in North-eastern Italy (Pellizzari, Porcelli 2013). It was reported for the first time in Europe (in the UK) in 1997 (Malumphy 1997), and later recorded in France, on plants imported from Italy (Germain,

Table 1. Scale insects recorded in Italy on ornamentals between 1945 and 2013

FAMILY	SPECIES	%
PSEUDOCOCCIDAE	*Balanococcus kwoni* Pellizzari & Danzig, 2007	39
	Chaetococcus bambusae (Maskell, 1892)	
	Delottococcus euphorbiae (Ezzat & McConnell, 1956)	
	Dysmicoccus brevipes (Cockerell, 1893)	
	Dysmicoccus mackenziei Beardsley, 1965	
	Dysmicoccus neobrevipes Beardsley, 1959	
	Ferrisia virgata (Cockerell, 1893)	
	Hypogeococcus pungens Granara de Willink, 1981	
	Nipaecoccus nipae (Maskell, 1893)	
	Phenacoccus defectus Ferris, 1950	
	Phenacoccus madeirensis Green, 1923	
	Phenacoccus peruvianus Granara de Willink, 2007	
	Phenacoccus solani Ferris, 1918	
	Planococcus halli Ezzat & McConnell, 1956	
	Pseudococcus comstocki (Kuwana, 1902)	
	Pseudococcus microcirculus McKenzie, 1960	
	Trochiscococcus speciosus (De Lotto, 1961)	
	Vryburgia brevicruris (McKenzie, 1960)	
	Vryburgia rimariae Tranfaglia, 1981	
RHIZOECIDAE	*Rhizoecus americanus* (Hambleton, 1946)	10
	Rhizoecus cacticans (Hambleton, 1946)	
	Rhizoecus dianthi Green, 1926	
	Rhizoecus latus (Hambleton, 1946)	
	Ripersiella hibisci (Kawai & Takagi, 1971)	
ERIOCOCCIDAE	*Acanthococcus mariannae* Pellizzari & Germain, 2010	10
	Eriococcus coccineus (Cockerell, 1894)	
	Ovaticoccus agavacearum Pellizzari & Kozar 2011	
	Ovaticoccus agavium (Douglas, 1888)	
	Ovaticoccus exoticus Pellizzari & Kozar 2011	
COCCIDAE	*Ceroplastes ceriferus* (Fabricius, 1798)	10
	Ceroplastes japonicus Green, 1921	
	Ceroplastes stellifer (Westwood, 1871)	
	Cryptinglisia lounsburyi Cockerell, 1900	
	Protopulvinaria pyriformis (Cockerell, 1894)	
HALIMOCOCCIDAE	*Limacoccus brasiliensis* (Hempel, 1934)	2
PHOENICOCOCCIDAE	*Phoenicococcus marlatti* Cockerell, 1899	2
DIASPIDIDAE	*Aspidiotus destructor* (Signoret, 1869)	27
	Aulacaspis tubercularis (Newstead, 1906)	
	Entaspidiotus lounsburyi (Marlatt, 1908)	
	Fiorinia pinicola Maskell, 1897	
	Gymnaspis aechmeae Newstead, 1898	
	Lopholeucaspis japonica (Cockerell, 1897)	
	Merceaspis isis (Hall, 1923)	
	Odonaspis greeni Cockerell, 1902	
	Pinnaspis strachani (Cooley, 1899)	
	Pseudaonidia paeoniae (Cockerell, 1899)	
	Pseudaulacaspis cockerelli (Cooley, 1897)	
	Selenaspidus albus McKenzie, 1953	
	Umbaspis regularis (Newstead, 1911)	

Matile-Ferrero 2006). It has spread to several species of succulents. This polyphagous species is morphologically very similar to *P. solani* Ferris and *P. solenopsis* Tinsley which are recent invaders into other countries of the Mediterranean basin (Israel, Sicily, Spain, Turkey) (Mazzeo *et al.* 1999; Ben-Dov 2005; Kaydan *et al.* 2008; Beltrà, Soto 2011).

Family Diaspididae

***Chrysomphalus aonidum* (Linnaeus, 1758)**

The Florida red scale was introduced into Italy a long time ago (Leonardi 1920), and was recorded in the 1990s in Sicily on *Cycas* in a nursery (Longo *et al.* 1994). The scale was originally considered a pest of ornamentals in greenhouses only, as it was apparently unable to survive outdoors. However, in 2007, it was recorded outdoors on *Citrus* in Southern Italy and is currently a serious problem in citrus orchards (Pellizzari, Vacante 2007). In Sicily, it has been detected also on ornamental bitter orange (*Citrus aurantium*) (Suma *et al.* 2013) and, in Liguria region, on *Kentia* (Pellizzari, Sacco 2010) plants.

***Aulacaspis tubercularis* (Newstead, 1906)**

Mango scale is a cryptoginic species, cosmopolitan and widespread in tropical and subtropical areas (Porcelli 1990). It is a very noxious pest, affecting the commercial value of mango fruits and their export potential wherever it is present (Nabil *et al.* 2012). In Italy, it was recorded in 1990 on mango trees in a nursery (Porcelli 1990). At the moment, this scale insect is included in the Alert List of the North Atlantic Plant Protection Organization (NAPPO) but, within European countries, it is not included in any list of the European and Mediterranean Plant Protection Organization (EPPO). Its polyphagy makes it a potential pest also for citrus groves, as happened in the case of *C. aonidum* (Conti *et al*. 2013).

Conclusions

Scale insects are major agricultural pests (Miller *et al*. 2005) and their economic importance is connected to their ability to hide on all parts of the host plants. In these niches, they can increase until their population causes serious damage. The newly introduced alien species arrive in new areas without their natural enemies and may find good conditions for survival. Often, they live in urban areas and here they can increase rapidly due to air pollution, urban warming, and absence or disruption by their natural enemies. A prominent role is probably played by global warming as this will directly influence the development and survival of the insects and can indirectly affect the trophic inter-relations between the phytophagous insects, their host plants and the presence of natural enemies. Although none of the scale species reported in Table 1 is in the Alert Lists of the European and Mediterranean Plant Protection Organization (OEPP, 2013), *R. hibisci* is included in the EPPO A1 list (OEPP, 2005), and so it is vitally important that greater efforts are made to prevent the spread of exotic insects throughout Europe (and beyond). Thus, there is a great need for tools to provide good, early detection of invading insects in order to promote prompt and effective action. In this context, an effective tool might be a study of an indicator species to act as a model to clarify the role of ecological factors (such as climate change) on the spread and acclimation of alien scale insects. In addition, a knowledge of which species are already invasive elsewhere (Samways, 1999), could be important, especially in forewarning organisations such as EPPO so as to promote and develop an international strategy against the introduction and spread of these pests.

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