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Updated list of intercepted Coccidae (Hemiptera: Coccomorpha) at South Korean ports of entry and potential invasive species to South Korea

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Updated list of intercepted Coccidae (Hemiptera: Coccomorpha) at South Korean ports of entry and potential invasive species to South Korea

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Abstract. An updated list is given of 25 species of soft scale insects (Hemiptera: Coccidae) which have been intercepted on plants imported into South Korea during the period of 1996 to 2021. Information on the number of interceptions, host plants, distribution and origin of species intercepted at South Korean ports of entry is provided. In addition, data on intercepted species was analyzed to determine potential invasive species of soft scales that could threaten South Korean plants.

Key words. Exotic species, plant trade, quarantine, soft scales.

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Introduction

Soft scale insects (Hemiptera: Coccomorpha: Coccidae) occur in all zoogeographical regions of the world. The Coccidae is the third largest family of scale insects (Hemiptera: Coccomorpha) with 1225 species in 178 genera known worldwide (García Morales et al. 2022). Biologically, soft scales which are plant feeders, can occur on just about any part of the plant but are especially common on the stems, leaves and fruits (Miller et al. 2014). Many species are significant economic pests of fruits and also landscaping plants (Hamon and Williams 1984; Gill 1988; Miller et al. 2014; Kondo and Watson 2022). Invasive species of insects which are not native, represent an increasing concern to South Korea since globalization has been facilitating the increase in plant trade, promoting the long-distance movement of pests attached on these plants (Mazzeo et al. 2014). If non-native species are able to establish in a different environment, they often become economic pests, resulting in yield losses, diminished product quality, increased production costs, especially in the application of chemical control measures which often have a deleterious effect on the environment, humans and the ecology of the agroecosystem (Huber et al. 2002; Miller and Miller 2003). Many soft scales are serious pests, particularly those that are invasive species. In South Korea there are 31 species (2.5%) of the soft scales known worldwide. Of these, seven species (22.6%) are likely invaders, namely *Ceroplastes rubens* Maskell, *Coccus ficicola* Choi and Lee, *Coccus hesperidum* Linnaeus, *Eucalymnatus tessellatus* (Signoret), *Parasaissetia nigra* (Nietner), *Saissetia coffeae* (Walker) and *Saissetia miranda* (Cockerell and Parrott). In South Korea, soft scales are usually found on imported plants that are grown inside greenhouses (Paik 1972; Paik 2000; Choi and Lee 2017; 2018). Recently species such as *C. ficicola* and *S. miranda* were discovered on banyan figs (*Ficus benghalensis* L.; Moraceae) in South Korean greenhouses (Choi and Lee 2017; 2018). The brown soft scale, *C. hesperidum*, is a serious pest not only outdoors, but also in greenhouses and internal landscape environments (Paik 1972; Paik 2000; Kwon and Han 2003; Kwon et al. 2005; Lee and Choi 2019).

To prevent the introductions of harmful insects along these pathways, countries apply biosecurity measures to imported plant goods and products, including visual inspections at the points of entry (Saccaggi et al. 2021). Therefore, being able to compile and update information on intercepted soft scales will help to improve the inspection procedures, to detect, identify and mitigate the damage caused by exotic invasive species. This paper provides an updated list of soft scales intercepted on imported plants into South Korea during the period of 1996 to 2021 based on records in the Pest Information System (PIS) database of South Korea. In addition, it deals with potential invasive species of soft scales that could threaten South Korean natural and agricultural environments.

Materials and Methods

Data on soft scales intercepted at ports of entry to South Korea on imported plants between 1996 and 2021 were extracted from the Pest Information System (PIS), a database developed by the Animal Plant Quarantine Agency (APQA). In total, 403 specimens of soft scales were intercepted during phytosanitary inspections on plants imported into South Korea from 1996 to 2021. The checklist contains the identification of soft scales intercepted at the ports of entry to the level of species or genus depending upon the quality of the sample and the life stage as well as a summary of their distribution and hosts based on data provided by Danzig (1980), Kawai (1980), Hamon and Williams (1984), Gill (1988), Kosztarab and Kozár (1988), Williams and Watson (1990), Tang (1991) and Kosztarab (1996). Of the total of specimens that were detected, approximately 73.2% (295 specimens), 14.1% (57) and 12.7% (51) of them were identified to species, genus and family level, respectively. It is difficult to determine the zoogeographical area of origin for some species. In some cases, the criteria such as the first reported location of the species, its current distribution, the distribution of what appears to be its closest relatives and the natural distribution of its primary host plants were considered to determine its probable origin. Slide-mounted specimens examined are deposited in the Collection of Plant Quarantine Technology Center (PQTC), APQA.

Results

A total of 25 species of scale insects in 11 genera were intercepted on plants imported from 24 countries into South Korea during the period of 1996 to 2021 (Table 1). Of soft scales detected at ports of entry during this survey, 41.9% (13 species) were not known to occur in South Korea at the time they were detected and 40% (10 species) are categorized as quarantine pests in South Korea. A list of the six species most frequently intercepted at South Korea ports of entry are *Coccus hesperidum* Linnaeus (62.2%), *Coccus viridis* (Green) (6.3%), *Saissetia oleae* (Olivier) (2.6%), *Ceroplastes ceriferus* (Fabricius) (2.6%), *Parasaissetia nigra* (Nietner) (1.7%) and *Pulvinaria psidii* Maskell (1.4%). Each of these species were intercepted more than five times at South Korean ports of entry and three species *C. hesperidum*, *Cer. ceriferus* and *P. nigra* have been reported to occur in the environment of South Korea. In terms of plants, *Skimmia* (cut flowers) constitutes 32.7% (115 times) of the interceptions and it is the most common intercepted host plant followed by *Musa* (leaves, fruits) at 7.4% (26) and *Citrus* (leaves, seedlings, fruits) at 5.4% (19).

The interception records from the past 26 years also were searched to determine which intercepted species of soft scales pose the greatest threat. While the possibility that other soft scales could invade South Korea exists, the following five species are considered to be the most likely candidates for next invasions into the South Korea. The stellate scale, *Ceroplastes stellifer* (Westwood) was first described on *Paphiopedilum niveum* (Orchidaceae) from Thailand. This species was intercepted once on *Dypsis* sp. (Arecaceae) from Malaysia and on *Garcinia* sp. (Clusiaceae) from Thailand at the South Korean ports of entry. Its host range (22 plant families) and distribution (59 countries) are relatively wide and it is considered a potential pest on crops and several ornamentals in Florida (Hamon and Williams 1984; García Morales et al. 2022; Peronti and Kondo 2022). The green scale, *Coccus viridis* (Green), was first described on coffee from Sri Lanka (Green 1889; García Morales et al. 2022). This species was found 22 times on plants such as *Camellia* (Theaceae) from Malaysia, *Dypsis* from China, *Heptapleurum* (Araliaceae) from China, Indonesia, Malaysia, *Ixora* (Rubiaceae) from Thailand, *Jatropha* (Euphorbiaceae) from Indonesia, *Gardenia* (Rubiaceae) from Indonesia, *Polyscias* (Araliaceae) from China, Indonesia, Malaysia and *Zamioculcas* (Araceae) from Taiwan in quarantine inspections. It is a serious pest of coffee, citrus and other crops in many tropical areas (Hamon and Williams 1984; Kondo et al. 2022). Almost all of its known hosts are from subtropical and tropical habitats. Therefore, it is likely to cause concern in greenhouses if this pest is introduced to South Korea. Plants used for propagation should be carefully examined for pests since the soft scale can often survive for longer periods of time on leaves. *Pulvinaria psidii* Maskell was first reported on a plant belonging to the genus *Psidium* (Myrtaceae) from Hawaii. This species was intercepted five times on plants such as *Coffea* sp. (Rubiaceae) from Vietnam, *Heptapleurum* (Araliaceae) from Costa Rica, *Litchi* (Sapindaceae) from China and *Nephelium* (Sapindaceae) from China. It is reported to be a pest of mango, *Mangifera* sp. (Anacardiaceae), in Egypt (Nada et al. 1990). The iceplant scale, *Pulvinariella mesembryanthemi* (Vallot) is a Palaearctic species

and was intercepted once on seedlings of *Mesembryanthemum* (Aizoaceae) from Australia. It is reported as a potential pest to Aizoaceae in California (García Morales et al. 2022). The black scale, *Saissetia oleae* (Olivier), was intercepted nine times on *Citrus* (Rutaceae) from Chile, New Zealand, *Durio* (Malvaceae) from Thailand, *Ficus* (Moraceae) from Japan, Malaysia and *Olea* (Oleaceae) from Italy, Netherlands at quarantine inspections. It is considered to be a major pest of citrus in many countries, and of olive in the Mediterranean region (Bodenheimer 1951; Bartlett 1978; Hamon and Williams 1984; Gill 1988; García Morales et al. 2022; Gavrilov-Zimin et al. 2022). Its hosts are primarily from subtropical and tropical habitats; however, citrus and olives, two of its known hosts can grow out of doors in the southern region of South Korea. Therefore, it is considered a potential threat to plants if introduced into Korea.

Discussion

The introduction of even a single species is of concern to South Korean environment, either in greenhouses or outdoor setting. If a pest can enter South Korea, over time there is a strong likelihood for establishment (Huber et al. 2002). Furthermore, scale insects reported as invasive pests in South Korea are sometimes only recognized after their populations have exploded to the point where they cause economic damage to plants. As a result, more appropriate and cost-effective quarantine procedures must be developed. One step in this procedure is to regularly update a list of pests intercepted on imported plants, identify potential invasive species which pose the greatest threat by analyzing information on intercepted pests and keep them under constant surveillance. Unfortunately, approximate 26.8% of the intercepted soft scales in South Korea are immatures which have not yet developed the diagnostic morphological characters required for confident identification or are older, poor quality adult female specimens which have these characteristics obscured and difficult to distinguish and evaluate (PIS 2022). Hence, the use of molecular tools like DNA barcodes may be useful in the identification of invasive scale insects and could be used to develop more effective pest management options for regulating pest species.

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Table 1. List of soft scale insects intercepted at South Korean ports of entry between 1996 to 2021. Codes for the zoographical regions recognized are as follows: NA, Nearctic; NT, Neotropical; PA, Palaearctic; OR, Oriental; AU, Australasian. [Total Int: number of intercepted records of soft scale species, In Kor: distributed in South Korea, Reg Orig: abbreviation of the zoographical region from where the species was first described, *: potential invasive species to South Korea.]

Species	Total Int	In Kor	Host Genus	Consignment origin	Reg Orig
Ceroplastes ceriferus (Fabricius)	9	yes	*Berzelia*	South Africa	OR
			Camellia	Japan	
			Ficus	China, Vietnam	
			Magnolia	Japan	
			Yucca	China	
			undetermined plant	Taiwan	
Ceroplastes cirripediformis Comstock	1	no	undetermined plant	Costa Rica	NA

Species	Total Int	In Kor	Host Genus	Consignment origin	Reg Orig
Ceroplastes japonicus Green	3	yes	*Chaenomeles*	Japan	PA
			Euonymus	Japan	
			undetermined plant	Italy	
Ceroplastes rubens Maskell	4	yes	*Mangifera*	Thailand	AU
			undetermined plant	Japan, Sri Lanka	
Ceroplastes rusci (Linnaeus)	2	no	*Pandanus*	Vietnam	PA
			undetermined plant	Israel	
**Ceroplastes stellifer* (Westwood)	2	no	*Dypsis*	Malaysia	OR
			Garcinia	Thailand	
Ceroplastes sp.	8	—	*Camellia*	China	—
			Eucalyptus	Indonesia	
			Podocarpus	Malaysia	
			undetermined plant	Israel, Italy, Malaysia, Sri Lanka	
Coccus hesperidum Linnaeus	219	yes	*Agave*	Poland	PA
			Asplenium	Japan	
			Banksia	South Africa	
			Berzelia	South Africa	
			Citrus	Chile, Thailand	
			Cordyline	Indonesia	
			Cymbidium	China, Japan	
			Dracaena	Indonesia	
			Durio	Thailand	
			Dypsis	China	
			Eryngium	Thailand, Vietnam	
			Eucalyptus	Indonesia	
			Ficus	China	
			Garcinia	Singapore	
			Gaultheria	USA	
			Heliconia	Thailand	
			Heptapleurum	China, Malaysia, Sri Lanka, Taiwan	
			Howea	China	
			Ixora	Thailand	
			Jasminum	Thailand	
			Mangifera	Indonesia	
			Musa	Colombia, Ecuador, Philippines, Thailand, Vietnam	
			Philodendron	Indonesia	
			Pittosporum	Indonesia, New Zealand	

Species	Total Int	In Kor	Host Genus	Consignment origin	Reg Orig
			Polyscias	Indonesia	
			Skimmia	Netherlands	
			Tradescantia	Sri Lanka	
			Vaccinium	Chile	
			Wrightia	Thailand	
			Zamioculcas	Sri Lanka, Taiwan	
			undetermined plant	Australia, China, Japan, Netherlands, Singapore, Thailand, Vietnam	
Coccus longulus (Douglas)	1	no	undetermined plant	Vietnam	PA
**Coccus viridis* (Green)	22	no	*Camellia*	Malaysia	OR
			Cymbidium	Japan	
			Dracaena	Philippines	
			Dypsis	China	
			Heptapleurum	China, Indonesia, Malaysia	
			Ixora	Thailand	
			Jatropha	Indonesia	
			Gardenia	Indonesia	
			Litchi	China	
			Musa	Vietnam	
			Polyscias	China, Indonesia, Malaysia	
			Synsepalum	Japan	
			Zamioculcas	Taiwan	
Coccus sp.	38	—	*Actinidia*	Chile	—
			Aloe	Italy	
			Garcinia	Thailand	
			Gaultheria	China, Netherlands, USA	
			Helleborus	Indonesia, Italy, Netherlands, Philippines	
			Jasminum	Vietnam	
			Leucadendron	South Africa	
			Musa	Philippines, Thailand	
			Prunus	Thailand, Uzbekistan	
			Skimmia	Netherlands	
			Vaccinium	USA	
			Veronica	Netherlands	
			undetermined plant	Madagascar, Malaysia	
Discochiton cocophyllae (Banks)	1	no	*Cocos*	Philippines	OR
Discochiton expansum (Green)	1	no	*Dypsis*	Malaysia	OR

Species	Total Int	In Kor	Host Genus	Consignment origin	Reg Orig
Drepanococcus chiton (Green)	1	no	*Dimocarpus*	Vietnam	OR
Milviscutulus mangiferae (Green)	3	no	*Cordyline*	Indonesia	OR
			Heptapleurum	Costa Rica	
Milviscutulus sp.	1	—	*Cordyline*	Sri Lanka	—
Parasaissetia nigra (Nietner)	6	yes	*Agave*	Indonesia	OR
			Citus	Thailand	
			Durio	Thailand	
			Musa	Philippines	
			Philodendron	Japan	
			undetermined tree	Thailand	
Parthenolecanium sp.	1	—	*Pittosporum*	Italy	—
Protopulvinaria pyriformis (Cockerell)	2	no	undetermined tree	Indonesia, Italy	NT
**Pulvinaria psidii* Maskell	5	no	*Coffea*	Vietnam	AU
			Heptapleurum	Costa Rica	
			Litchi	China	
			Nephelium	China	
			undetermined plant	Vietnam	
Pulvinaria sp.	2	—	*Dimocarpus*	Vietnam	—
			undetermined plant	New Zealand	
**Pulvinariella mesembryanthemi* (Vallot)	1	no	*Mesembryanthemum*	Australia	PA
Saissetia coffeae (Walker)	3	yes	*Asplenium*	Japan	OR
**Saissetia oleae* (Olivier)	9	no	*Citrus*	Chile, New Zealand	PA
			Durio	Thailand	
			Ficus	Japan, Malaysia	
			Olea	Italy, Netherlands	
Saissetia sp.	7	—	*Codiaeum*	Sri Lanka	—
			Cymbidium	Japan	
			Durio	China, Thailand	
			Eryngium	Vietnam	
			undetermined plant	Indonesia	

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