

List of Intercepted Scale Insects at Korean Ports of Entry and Potential Invasive Species of Scale Insects to Korea (Hemiptera: Coccoidea)

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우리나라 입항지에서 검출된 깍지벌레 목록 및 침입이 우려되는 깍지벌레 (노린재목, 깍지벌레상과)

서수정 · 유혜미 · 홍기정¹

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ABSTRACT: An updated list is given of 113 species of scale insects which have been intercepted on plants imported into Korea during the period of 2007 to 2011. Information on the number of interceptions, origin, host plants and distribution of species intercepted at Korean ports of entry is provided. In addition, data on intercepted species was analyzed to determine potential invasive species of scale insects that could threaten Korean plants.

Key words: Scale insects, Invasive species, Quarantine, Korea

초록: 2007년부터 2011년 사이 우리나라로 수입된 식물류에서 검출된 113종의 깍지벌레 목록을 정리하였으며, 이들 종들의 검출횟수, 기원, 기주식물 및 분포에 대한 자료도 추가하였다. 한편, 동 자료의 분석을 통해 국내 유입시 식물에 피해를 줄 것으로 예상되는 깍지벌레 종에 대한 정보를 제공하고자 한다.

검색어: 깍지벌레, 침입종, 검역, 한국

The general trend of the amount of plant material imported into Korea has been upward from 2007 to 2011, although was slightly less in 2008 and 2009 (Table 1). Numerous kinds of pests were intercepted during import inspections (1,004 species, 47,637 interceptions). Of these, scale insects composed 43 percent (113 species, 20,610 interceptions) of the interceptions (PIS, 2012).

Scale insects (Coccoidea) are plant feeders that have a more or less cryptic way of life because of their small size and limited mobility. They are almost always found associated with plants,

and are commonly intercepted on imported plant materials. As a result, they can easily be transported to other areas on the plants on which they live. Some 25% of the exotic species that have become established in the USA apparently belong to scale insects (Miller et al., 2005). In Korea, 102 exotic species have been documented from 1900 to 2012; of these, 6 species are scale insects (Park, 2010). The number of exotic species of insect pests in Korea by different periods stood at 2 species in 1970s, 5 species in 1980s, 12 species in 1990s and 8 species in 2000s. It is clear that the number of invasive species increases considerably with international trades for plants.

The introduction of an exotic species has often been followed by large outbreaks in their population and subsequent economic

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damage to plants. The cycad aulacaspis species, *Aulacaspis yasumatsui* Takagi, was an obscure species in southeast Asia in the 1970s where it was first discovered. However, recently it has spread to other regions of the world where its population has exploded and has become a major pest of cycads in many other countries in the world where it has spread rapidly by the international trade of cycads. Korea imports large quantities of plant material from many countries of the world each year. Therefore, preventive actions are required to prevent the entry and establishment of invasive species.

This paper provides an updated list of scale insects intercepted from imported plants including fruits, vegetables, shrubs, trees, cut-flowers and cuttings etc. into Korea during the period of 2007 to 2011. In addition, it deals with potential invasive species of scale insects that could threaten Korean crops by analyzing information on intercepted species.

Materials and Methods

Data of scale insects intercepted at Korean ports of entry on imported plants from 2007 to 2011 (Table 1) was extracted from the Pest Information System (PIS) (2012). Information on the number of scale insect species known to occur in the Korean Peninsula and in seven zoogeographic regions (Table 2) was gathered to papers related to Korean scale insects (Paik, 2000; Suh and Hodges, 2007; Lee, 2010; Lee and Suh, 2011; Suh, 2011; 2012) and ScaleNet, a website that includes information on all of the species of scale insects that has been published worldwide (Ben-Dov et al., 2012). Seven zoogeographic regions are as follows: Nearctic (NE), Neotropical (NT), Afrotropical (AF), Palearctic (PA), Oriental (OR), Australasian (AU) and Antarctica (AN). Contrary to ScaleNet which divides parts of Mexico and China into two different regions, in this work all of Mexico is included in the Nearctic region and all of China is placed in the Oriental region.

The present updated list of scale insects intercepted from imported plants (Table 3) is based on records of the PIS

database. A total of 113 species of scale insects were intercepted at Korean ports of entry from 1,634 consignments of plants originating from about 148 countries in the world during the past five years (2007 to 2011). This list contains the identification of specimens to the level of species or genus depending upon the quality of the sample, the life stage that was intercepted and the current taxonomic knowledge of the taxon. An asterisk(*) in Table 3 is used to indicate potential invasive species to Korea based on their pest status, known hosts and distribution and the number of times they were intercepted.

The nomenclature used here for the Coccoidea follows that of the ScaleNet database (Ben-Dov et al., 2012). Species that were intercepted that are known to occur outdoors in Korea are not addressed here.

Results and Discussion

There are about 7,500 known species of scale insects (Coccoidea) of 45 families (extant and fossil) worldwide and among them, 188 species belonging to 15 families have been reported in Korea. The following families form the main groups: Diaspididae (76 species), Pseudococcidae (44 species), Coccidae (32 species) and Eriococcidae (14 species) and the other families are each represented by only one or a few species. The number of species in these families that are known to occur in the Korea and in the seven zoogeographic regions is shown in Table 2. Korean scale insects make up only about three percent of the total number of species that are known worldwide and therefore the others as exotic species could enter and establish into Korea. In fact, not all invasive species become major pest species, however, any scale insect species that has been separated from its natural enemies and can survive the environmental condition in its new environment, has the potential to become a pest species in its non-native habitat.

A total number of species found during the period 2007 to 2011 comprises 113 species from 7 families (Table 3). Soft scales (Coccidae; 12 species), armored scales (Diaspididae; 52

Table 1. Quarantine record on imported plants from 2007 to 2011 [case: number of quarantine inspections of imported plants]

Year	2007	2008	2009	2010	2011
Inspected case	90,221	82,072	80,658	100,184	105,849

Table 2. Number of scale insect species known to occur in the Korean Peninsula and in the seven zoogeographic regions, and the percentage of the total number of known species

Region	Acleridae		Asterolecaniidae		Beesoniidae		Cerococcidae	
	Total species	% / total species	Total species	% / total species	Total species	% / total species	Total species	% / total species
Korea	1	2	2	1	1	6	1	1
Afrotropical	10	17	25	10	0	0	17	24
Antarctica	0	0	0	0	0	0	0	0
Australasian	2	3	35	15	1	6	11	15
Nearctic	20	34	29	12	0	0	8	11
Neotropical	7	12	51	21	4	25	10	14
Oriental	14	24	105	44	11	69	19	26
Palaeartic	13	22	74	31	1	6	18	25
Worldwide	58	100	240	100	16	100	72	100
Region	Coccidae		Conchaspidae		Diaspididae		Eriococcidae	
	Total species	% / total species	Total species	% / total species	Total species	% / total species	Total species	% / total species
Korea	32	3	0	0	76	3	14	2
Afrotropical	275	24	16	53	574	23	9	1
Antarctica	0	0	0	0	1	0	0	0
Australasian	164	14	3	10	434	17	274	41
Nearctic	162	14	4	13	422	17	91	14
Neotropical	312	27	8	27	378	15	84	13
Oriental	431	38	6	20	935	37	42	6
Palaeartic	289	25	1	3	645	26	187	28
Worldwide	1,146	100	30	100	2,512	100	668	100
Region	Kermesidae		Kuwaniidae		Lecandiaspididae		Matsucoccidae	
	Total species	% / total species	Total species	% / total species	Total species	% / total species	Total species	% / total species
Korea	4	4	1	8	2	2	2	5
Afrotropical	1	1	1	8	13	16	0	0
Antarctica	0	0	0	0	0	0	0	0
Australasian	0	0	0	0	23	28	0	0
Nearctic	34	37	2	15	8	10	18	43
Neotropical	0	0	0	0	8	10	3	7
Oriental	24	26	5	38	27	33	5	12
Palaeartic	40	44	7	54	6	7	14	33
Worldwide	91	100	13	100	82	100	42	100
Region	Monophlebidae		Ortheziidae		Pseudococcidae		Steingeliidae	
	Total species	% / total species	Total species	% / total species	Total species	% / total species	Total species	% / total species
Korea	5	2	2	1	44	2	1	10
Afrotropical	62	26	39	19	298	13	0	0
Antarctica	0	0	0	0	0	0	0	0
Australasian	41	17	22	11	459	20	4	40
Nearctic	23	10	42	21	424	19	4	40
Neotropical	40	17	64	32	283	13	0	0
Oriental	73	31	27	13	431	19	0	0
Palaeartic	31	13	27	13	710	32	3	30
Worldwide	239	100	203	100	2,247	100	10	100

Table 3. List of scale insects (Coccoidea) intercepted at Korean ports of entry between 2007 to 2011 [Total Int: number of intercepted records of scale insect species, Reg Orig: abbreviation of the region from where the species was first described, In Kor: distributed in Korea, ?: unknown, specimens not examined even though known as greenhouse species in Korea, F: fruits, *: potential invasive species to Korea]

Species	Total Int	Reg Orig	In Kor	Host Genus (shipment origin)
Asterolecaniidae				
<i>Bambusaspis bambusae</i> (Boisduval)	4	PA	yes	<i>Phyllostachys</i> (China)
* <i>Planchonia stentae</i> (Brain)	1	AF	no	<i>Echeveria</i> (Mexico)
Coccidae				
<i>Ceroplastes ceriferus</i> (Fabricius)	4	OR	yes	<i>Ficus</i> (China, Vietnam) <i>Yucca</i> (China)
<i>Ceroplastes rusci</i> (Linnaeus)	1	PA	no	undetermined tree (Israel)
<i>Ceroplastes</i> sp.	1	-	-	undetermined tree (Malaysia)
* <i>Ceroplastes stellifer</i> (Westwood)	1	OR	no	<i>Chrysalidocarpus</i> (Malaysia)
<i>Coccus hesperidum</i> Linnaeus	38	PA	yes	<i>Berzelia</i> (South Africa) <i>Citrus</i> (F; Chile) <i>Citrus</i> (Thailand) <i>Ficus</i> (China) <i>Heliconia</i> (Thailand) <i>Musa</i> (F; Philippines, Thailand) <i>Pittosporum</i> (Indonesia) <i>Protea</i> (South Africa) <i>Schefflera</i> (Malaysia, China, Taiwan) <i>Skimmia</i> (Netherlands) <i>Tradescantia</i> (Sri Lanka) <i>Wrightia</i> (Thailand) <i>Zamioculcas</i> (Sri Lanka) other (Netherlands, Thailand, Australia)
<i>Coccus longulus</i> (Douglas)	1	PA	no	<i>Ficus</i> (Malaysia)
<i>Coccus</i> sp.	3	-	-	<i>Actinidia</i> (F; Chile) <i>Jasminum</i> (Vietnam) other (Philippines)
* <i>Coccus viridis</i> (Green)	12	OR	no	<i>Chrysalidocarpus</i> (China) <i>Jatropha</i> (Indonesia) <i>Polyscias</i> (Indonesia) <i>Schefflera</i> (Malaysia, China) <i>Zamioculcas</i> (Taiwan) other (Malaysia)
<i>Milviscutulus mangiferae</i> (Green)	1	OR	no	<i>Cordyline</i> (Indonesia)
<i>Paralecanium expansum</i> (Green)	1	OR	no	<i>Chrysalidocarpus</i> (Malaysia)
<i>Parasaissetia nigra</i> (Nietner)	1	OR	yes	<i>Citrus</i> (Thailand)
<i>Pulvinaria psidii</i> Maskell	2	AU	no	<i>Coffea</i> (Vietnam) <i>Schefflera</i> (Costa Rica)
* <i>Pulvinariella mesembryanthemi</i> (Vallot)	1	PA	no	<i>Mesembryanthemum</i> (Australia)
* <i>Saissetia oleae</i> (Olivier)	4	PA	no	<i>Durio</i> (F; Thailand) <i>Ficus</i> (Malaysia) <i>Olea</i> (Netherlands)
Conchaspidae				
* <i>Conchaspis angraeci</i> Cockerell	2	AF	no	<i>Codiaeum</i> (Indonesia) <i>Schefflera</i> (Malaysia)

Species	Total Int	Reg Orig	In Kor	Host Genus (shipment origin)
Diaspididae				
<i>Abgrallaspis aguacatae</i> Evans, Watson & Miller	1	NE	no	<i>Persea</i> (F; Mexico)
* <i>Abgrallaspis cyanophylli</i> (Signoret)	4	PA	no	<i>Crassula</i> (USA) other (China)
* <i>Aonidiella aurantii</i> (Maskell)	115	AU	no	<i>Citrus</i> (F; USA, Australia) <i>Citrus</i> (Thailand) <i>Dracaena</i> (Malaysia) <i>Nerium</i> (Thailand)
* <i>Aonidiella orientalis</i> (Newstead)	1	OR	no	undetermined cut flower (Malaysia)
<i>Aonidiella</i> sp.	2	-	-	<i>Citrus</i> (F; USA) <i>Ficus</i> (China)
<i>Aspidiotus destructor</i> Signoret	8	AF	yes	<i>Chrysalidocarpus</i> (Malaysia) <i>Heliconia</i> (Thailand) <i>Rhapis</i> (China)
* <i>Aspidiotus excisus</i> Green	2,983	OR	no	<i>Ananas</i> (F; Philippines) <i>Musa</i> (F; Philippines, Sri Lanka, Malaysia, Thailand, China, Guatemala, Ecuador, Peru) <i>Vitis</i> (F; Chile)
<i>Aspidiotus nerii</i> Bouche	41	PA	?	<i>Actinidia</i> (F; New Zealand) <i>Citrus</i> (F; USA) <i>Cocos</i> (F; Malaysia) <i>Leucospermum</i> (South Africa, Australia) <i>Protea</i> (New Zealand)
* <i>Aulacaspis yasumatsui</i> Takagi	13	OR	no	<i>Cycas</i> (China, Taiwan, Philippines)
<i>Chrysomphalus aonidium</i> (Linnaeus)	13	PA	?	<i>Chrysalidocarpus</i> (Malaysia) <i>Dracaena</i> (China, Indonesia, Sri Lanka, Costa Rica) <i>Rhapis</i> (China) other (China)
<i>Chrysomphalus bifasciculatus</i> Ferris	1	NE	yes	<i>Rhapis</i> (China)
* <i>Diaspidiotus ancylus</i> (Putnam)	1	NE	no	<i>Actinidia</i> (F; New Zealand)
<i>Diaspidiotus perniciosus</i> (Comstock)	1	NE	yes	<i>Actinidia</i> (F; USA)
<i>Diaspis boisduvalii</i> Signoret	13	PA	?	<i>Ananas</i> (F; Philippines, Singapore, Indonesia) <i>Musa</i> (F; Ecuador) <i>Opuntia</i> (Germany)
<i>Diaspis bromeliae</i> (Kerner)	2	NT	?	<i>Ananas</i> (F; Philippines)
<i>Diaspis echinocacti</i> (Bouche)	3	PA	?	<i>Gymnocalycium</i> (China) <i>Hylocereus</i> (F; Vietnam) other (China)
<i>Duplachionaspis divergens</i> (Green)	6	OR	no	<i>Cymbopogon</i> (Thailand, Cambodia)
<i>Fiorinia coronata</i> Williams & Watson	4	AU	no	<i>Chrysalidocarpus</i> (Malaysia) <i>Ficus</i> (Thailand) other (Mayasia)
<i>Fiorinia</i> sp.	1	-	-	<i>Jasminum</i> (Vietnam)
<i>Furcaspis bififormis</i> (Cockerell)	1	AF	no	<i>Pedilanthus</i> (Indonesia)
<i>Hemiberlesia lataniae</i> (Signoret)	91	PA	?	<i>Actinidia</i> (F; USA, New Zealand, Chile) <i>Alocasia</i> (China) <i>Chrysalidocarpus</i> (Malaysia, Vietnam) <i>Citrus</i> (F; USA, Chile) <i>Cucurbita</i> (F; Tonga) <i>Cycas</i> (China) <i>Leucospermum</i> (Australia)

Species	Total Int	Reg Orig	In Kor	Host Genus (Shipment origin)
<i>Hemiberlesia lataniae</i> (Signoret)				<i>Mangifera</i> (China) <i>Persea</i> (F; USA, New Zealand, Mexico) <i>Protea</i> (Australia)
* <i>Hemiberlesia palmae</i> (Cockerell)	13	AF	no	<i>Chrysalidocarpus</i> (Malaysia) <i>Cordyline</i> (Malaysia) <i>Musa</i> (F; Philippines)
* <i>Hemiberlesia rapax</i> (Comstock)	59	PA	no	<i>Actinidia</i> (F; New Zealand, Chile) <i>Citrus</i> (F; USA) <i>Cocos</i> (F; Philippines) <i>Cucurbita</i> (F; New Zealand) <i>Persea</i> (F; USA, New Zealand) <i>Vitis</i> (F; Chile)
<i>Hemiberlesia</i> sp.	6	-	-	<i>Persea</i> (F; USA)
* <i>Howardia biclavis</i> (Comstock)	6	NE	no	<i>Plumeria</i> (Indonesia) other (Malaysia)
<i>Kuwanaspis howardi</i> (Cooley)	2	OR	yes	<i>Phyllostachys</i> (Japan)
* <i>Lepidosaphes beckii</i> (Newman)	123	PA	no	<i>Citrus</i> (F; USA, Chile) <i>Dracaena</i> (Indonesia, China) <i>Schefflera</i> (Philippines) other (Vietnam)
<i>Lepidosaphes chinensis</i> Chamberlin	7	OR	no	<i>Rhapis</i> (China) <i>Cycas</i> (China)
<i>Lepidosaphes gloverii</i> (Packard)	2	NE	yes	<i>Citrus</i> (F; USA)
* <i>Lepidosaphes laterochitinoso</i> Green	44	PA	?	<i>Dracaena</i> (Indonesia, Philippines, Malaysia, Vietnam) <i>Sansevieria</i> (Indonesia, China)
<i>Lepidosaphes tapleyi</i> Williams	1	AF	no	<i>Cocos</i> (F; Malaysia)
* <i>Lepidosaphes tokionis</i> (Kuwana)	9	PA	no	<i>Codiaeum</i> (Sri Lanka) <i>Dracaena</i> (Indonesia, China) <i>Sansevieria</i> (Indonesia)
<i>Lepidosaphes ulmi</i> (Linnaeus)	1	PA	yes	<i>Punica</i> (Uzbekistan)
* <i>Lindingaspis rossi</i> (Maskell)	1	AU	no	<i>Leucadendron</i> (Australia)
<i>Lopholeucaspis japonica</i> (Cockerell)	1	PA	yes	<i>Acer</i> (Japan)
<i>Melanaspis bromiliae</i> (Leonardi)	13	AF	no	<i>Ananas</i> (F; Philippines)
* <i>Morganella longispina</i> (Morgan)	1	NT	no	<i>Citrus</i> (F; USA)
<i>Octaspidiotus stauntoniae</i> (Takahashi)	1	OR	no	<i>Jasminum</i> (Vietnam)
<i>Parlatoreopsis chinensis</i> (Marlatt)	1	OR	no	<i>Styphnolobium</i> (China)
* <i>Parlatoria cinerea</i> Hadden	3	AU	no	<i>Citrus</i> (Thailand) <i>Stephanotis</i> (China)
<i>Parlatoria pergandii</i> Comstock	10	NE	yes	<i>Citrus</i> (F; USA)
* <i>Parlatoria pittospori</i> Maskell	1	AU	no	<i>Paranomus</i> (South Africa)
<i>Parlatoria proteus</i> (Curtis)	9	PA	?	<i>Dracaena</i> (Malaysia, Vietnam, Taiwan) <i>Sansevieria</i> (Indonesia, China)
* <i>Parlatoria ziziphi</i> (Lucas)	53	PA	no	<i>Citrus</i> (Thailand) other (Australia)
<i>Pinnaaspis aspidistrae</i> (Signoret)	15	PA	yes	<i>Citrus</i> (F; USA) <i>Cymbidium</i> (China) <i>Dracaena</i> (Costa Rica, Taiwan) <i>Musa</i> (F; Philippines) <i>Sansevieria</i> (Indonesia)
<i>Pinnaaspis buxi</i> (Bouche)	3	PA	?	<i>Cordyline</i> (Malaysia, Indonesia) <i>Ixora</i> (Vietnam)

Species	Total Int	Reg Orig	In Kor	Host Genus (Shipment origin)
<i>Pinnaspis musae</i> Takagi	108	OR	no	<i>Musa</i> (F; Philippines)
<i>Pinnaspis strachani</i> (Cooley)	2	AF	?	<i>Dracaena</i> (Costa Rica) other (Indonesia)
<i>Pseudaonidia paeoniae</i> (Cockerell)	2	NE	yes	<i>Rhododendron</i> (Japan)
* <i>Pseudaonidia trilobitiformis</i> (Green)	1	OR	no	<i>Ficus</i> (China)
<i>Pseudaulacaspis cockerelli</i> (Cooley)	39	OR	yes	<i>Berzelia</i> (Australia) <i>Chrysalidocarpus</i> (Malaysia) <i>Cocos</i> (F; Indonesia) <i>Cymbopogon</i> (Thailand) <i>Dracaena</i> (China) <i>Ficus</i> (Indonesia) <i>Jasminum</i> (Vietnam) <i>Leucadendron</i> (South Africa, Australia) <i>Leucospermum</i> (Australia) <i>Palmae</i> (Indonesia) <i>Stephanotis</i> (China) other (China, Malaysia, Australia)
<i>Pseudaulacaspis eugeniae</i> (Maskell)	1	AU	no	<i>Xanthorrhoea</i> (Australia)
<i>Pseudaulacaspis pentagona</i> (Targioni-Tozzetti)	57	PA	yes	<i>Actinidia</i> (F; Japan, New Zealand) <i>Carica</i> (F; USA) <i>Chimonanthus</i> (China) <i>Codiaeum</i> (Indonesia, Thailand) <i>Dracaena</i> (Indonesia) <i>Fraxinus</i> (China) <i>Juglans</i> (China) <i>Lantana</i> (Indonesia) <i>Morus</i> (Taiwan) <i>Plumeria</i> (Indonesia, Sri Lanka) <i>Polyscias</i> (Indonesia) <i>Prunus</i> (Japan) <i>Schefflera</i> (Indonesia) <i>Styphnolobium</i> (China) other (Indonesia)
<i>Pseudaulacaspis</i> sp.	2	-	-	<i>Ananas</i> (F; Philippines) <i>Prunus</i> (F; China)
<i>Rolaspis lounsburyi</i> (Cooley)	1	AF	no	<i>Phyllica</i> (South Africa)
* <i>Unaspis citri</i> (Comstock)	1	NE	no	<i>Citrus</i> (F; USA)
Eriococcidae				
<i>Acanthococcus coccineus</i> Cockerell	1	NE	no	<i>Echeveria</i> (Japan)
<i>Eriococcus lagerstroemiae</i> Kuwana	1	PA	yes	<i>Lagerstroemia</i> (China)
Monophlebidae				
* <i>Icerya seychellarum</i> (Westwood)	1	AF	no	undetermined tree (China)
<i>Icerya</i> sp.	2			<i>Berzelia</i> (Australia) other (Thailand)
Pseudococcidae				
<i>Atrococcus paludimus</i> (Green)	1	PA	yes	<i>Codonopsis</i> (China)
* <i>Dysmicoccus brevipes</i> (Cockerell)	4,763	AF	no	<i>Agave</i> (Indonesia) <i>Alocasia</i> (Indonesia)

Species	Total Int	Reg Orig	In Kor	Host Genus (Shipment origin)
* <i>Dysmicoccus brevipes</i> (Cockerell)				<i>Ananas</i> (F; Philippines, Thailand, Indonesia, Singapore, Sri Lanka, Vietnam, Malaysia, China, Taiwan, USA, Panama, Costa Rica, Honduras) <i>Ananas</i> (Netherlands, Taiwan) <i>Chrysalidocarpus</i> (Thailand) <i>Citrus</i> (F; USA) <i>Citrus</i> (Thailand) <i>Ficus</i> (China) <i>Heliconia</i> (Thailand, Malaysia) <i>Heteropanax</i> (China) <i>Howea</i> (Vietnam) <i>Musa</i> (F; Philippines) <i>Polyscias</i> (Indonesia) <i>Rhapis</i> (China) <i>Rhizophora</i> (Vietnam) <i>Schefflera</i> (China) other (Taiwan, Malaysia)
* <i>Dysmicoccus neobrevipes</i> Beardsley	10,936	AU	no	<i>Agave</i> (Indonesia) <i>Aglaonema</i> (Thailand) <i>Ananas</i> (F; Costa Rica, China, Philippines) <i>Heliconia</i> (Thailand) <i>Musa</i> (F; Philippines, Peru, Thailand, China, Indonesia, Ecuador, Sri Lanka, Malaysia, Taiwan, Guatemala) <i>Schefflera</i> (Malaysia, Philippines, Taiwan, China) <i>Tillandsia</i> (Thailand) <i>Yucca</i> (China, Indonesia) other (Philippines)
<i>Dysmicoccus</i> sp.	40	-	-	<i>Actinidia</i> (F; New Zealand) <i>Codiaeum</i> (Sri Lanka, Indonesia) <i>Dracaena</i> (Costa Rica) <i>Durio</i> (F; Thailand) <i>Heliconia</i> (Thailand, Malaysia) <i>Heteropanax</i> (China) <i>Musa</i> (F; Philippines) <i>Polyscias</i> (Costa Rica) <i>Schefflera</i> (Malaysia)
* <i>Ferrisia virgata</i> (Cockerell)	10	AF	no	<i>Citrus</i> (F; USA) <i>Agave</i> (Indonesia) <i>Ananas</i> (Taiwan) <i>Codiaeum</i> (Costa Rica) <i>Dieffenbachia</i> (Vietnam) <i>Dracaena</i> (Costa Rica) <i>Echeveria</i> (Japan) <i>Musa</i> (F; Philippines) other (Malaysia)
* <i>Maconellicoccus hirsutus</i> (Green)	5	OR	no	<i>Areca</i> (China) <i>Ficus</i> (Vietnam, China) <i>Musa</i> (F; Philippines)
<i>Neotrionymus monstata</i> Borchsenius	1	PA	no	<i>Arundo</i> (China)
<i>Nipaecoccus</i> sp.	1	-	-	<i>Leucadendron</i> (Philippines)

Species	Total Int	Reg Orig	In Kor	Host Genus (Shipment origin)
* <i>Nipaecoccus viridis</i> (Newstead)	3	OR	no	<i>Citrus</i> (Thailand)
<i>Paracoccus</i> sp.	8	-	-	<i>Codiaeum</i> (Indonesia) <i>Dracaena</i> (Indonesia) <i>Echeveria</i> (Brazil, Mexico) <i>Leucospermum</i> (Netherlands) <i>Opuntia</i> (Netherlands) <i>Radermachera</i> (China) <i>Schefflera</i> (China)
* <i>Phenacoccus madeirensis</i> Green	2	PA	no	<i>Ocimum</i> (China) other (Ecuador)
* <i>Phenacoccus solani</i> Ferris	15	NE	no	<i>Aeonium</i> (Italy) <i>Crassula</i> (Japan) <i>Echeveria</i> (China, Netherlands, Indonesia, Brazil, Japan) <i>Graptoveria</i> (Japan) <i>Pachyphytum</i> (Netherlands)
<i>Phenacoccus solenopsis</i> Tinsley	5	NE	no	<i>Ananas</i> (F; Philippines) <i>Euphorbia</i> (Vietnam) <i>Ficus</i> (China) <i>Polyscias</i> (Philippines) other (Thailand)
<i>Phenacoccus</i> sp.	5	-	-	<i>Durio</i> (F; Thailand) <i>Polyscias</i> (Vietnam) other (Netherlands)
<i>Planococcus citri</i> (Risso)	71	PA	yes	<i>Chrysanthemum</i> (Vietnam) <i>Citrus</i> (F; USA, Chile) <i>Citrus</i> (Thailand) <i>Codiaeum</i> (Thailand, China) <i>Echeveria</i> (Italy, USA, Japan) <i>Ficus</i> (Vietnam, China) <i>Heliconia</i> (Thailand) <i>Heteropanax</i> (China) <i>Kalanchoe</i> (China) <i>Leucospermum</i> (South Africa) <i>Philodendron</i> (China) <i>Polyscias</i> (Indonesia) <i>Schefflera</i> (Malaysia, China) <i>Vitis</i> (F; USA) other (Thailand)
<i>Planococcus ficus</i> (Signoret)	4	PA	no	<i>Vitis</i> (F; USA)
<i>Planococcus kraunhiae</i> (Kuwana)	3	PA	yes	<i>Diospyros</i> (F; Japan) <i>Dracaena</i> (Philippines) <i>Polyscias</i> (Philippines)
* <i>Planococcus lilacinus</i> (Cockerell)	5	OR	no	<i>Dimocarpus</i> (China) <i>Ficus</i> (China) <i>Philodendron</i> (China)
<i>Planococcus minor</i> (Maskell)	53	AF	no	<i>Agave</i> (Indonesia) <i>Ananas</i> (F; Indonesia) <i>Chrysalidocarpus</i> (Thailand) <i>Codiaeum</i> (Indonesia, Thailand) <i>Crinum</i> (Indonesia) <i>Dracaena</i> (Indonesia)

Species	Total Int	Reg Orig	In Kor	Host Genus (Shipment origin)
<i>Planococcus minor</i> (Maskell)				<i>Durio</i> (F; Thailand) <i>Ficus</i> (Indonesia, Philippines, Vietnam) <i>Ixora</i> (Vietnam) <i>Jatropha</i> (Indonesia) <i>Polyscias</i> (Indonesia) <i>Rhizophora</i> (Vietnam) <i>Schefflera</i> (Malaysia, Taiwan, Indonesia) <i>Tragopogon</i> (Vietnam) other (Indonesia, Thailand, Malaysia)
<i>Planococcus</i> sp.	30	-	-	<i>Ananas</i> (Thailand) <i>Ammonia</i> (Taiwan) <i>Aralia</i> (China) <i>Citrus</i> (F; USA, Chile) <i>Codiaeum</i> (Indonesia) <i>Durio</i> (F; Thailand) <i>Echeveria</i> (Italy) <i>Ficus</i> (China) <i>Heteropanax</i> (China) <i>Polyscias</i> (Indonesia) <i>Schefflera</i> (China) other (Vietnam, Australia)
<i>Pseudococcus baliteus</i> Lit	1	OR	no	<i>Polyscias</i> (Indonesia)
* <i>Pseudococcus calceolariae</i> (Maskell)	38	AU	no	<i>Citrus</i> (F; Chile, Australia, USA) <i>Protea</i> (South Africa) <i>Vitis</i> (F; Chile)
<i>Pseudococcus comstocki</i> (Kuwana)	14	PA	yes	<i>Codiaeum</i> (Indonesia) <i>Ficus</i> (China) <i>Heteropanax</i> (China) <i>Styphnolobium</i> (China)
<i>Pseudococcus cryptus</i> Hempel	6	NT	yes	<i>Citrus</i> (Thailand) <i>Ficus</i> (China) <i>Heliconia</i> (Thailand) <i>Ixora</i> (Indonesia)
* <i>Pseudococcus elisae</i> Borchsenius	12	NT	no	<i>Codiaeum</i> (Thailand) <i>Dracaena</i> (Costa Rica) <i>Musa</i> (F; Colombia, Mexico) <i>Nerium</i> (Thailand) <i>Polyscias</i> (Indonesia, Costa Rica)
<i>Pseudococcus jackbeardsleyi</i> Gimpel & Miller	21	NE	no	<i>Citrus</i> (Thailand) <i>Codiaeum</i> (Thailand) <i>Cordyline</i> (Malaysia) <i>Dracaena</i> (Costa Rica) <i>Heteropanax</i> (China) <i>Jatropha</i> (Indonesia) <i>Nerium</i> (Thailand) <i>Polyscias</i> (Indonesia) other (Malaysia)
* <i>Pseudococcus longispinus</i> (Targioni-Tozzetti)	389	PA	?	<i>Actinidia</i> (F; New Zealand) <i>Agave</i> (Indonesia) <i>Aglaonema</i> (Thailand) <i>Alocasia</i> (Indonesia, China) <i>Berzelia</i> (Australia)

Species	Total Int	Reg Orig	In Kor	Host Genus (Shipment origin)
* <i>Pseudococcus longispinus</i> (Targioni-Tozzetti)				<i>Bougainvillea</i> (Indonesia) <i>Chrysalidocarpus</i> (Malaysia) <i>Citrus</i> (Chile, USA, Australia) <i>Codiaeum</i> (Indonesia, Sri Lanka, Vietnam) <i>Cordyline</i> (Indonesia) <i>Dracaena</i> (Indonesia, Philippines, Malaysia, Taiwan, China, Sri Lanka, Costa Rica) <i>Echeveria</i> (Netherlands) <i>Ficus</i> (China, Malaysia, Indonesia, Vietnam) <i>Heteropanax</i> (China) <i>Jatropha</i> (Indonesia) <i>Kalanchoe</i> (Netherlands) <i>Mascarena</i> (Taiwan) <i>Opuntia</i> (Germany) <i>Palmae</i> (Malaysia) <i>Philodendron</i> (China) <i>Plumeria</i> (Indonesia) <i>Polyscias</i> (Indonesia, Thailand, Philippines, Costa Rica) <i>Protea</i> (South Africa, Australia) <i>Radermachera</i> (China) <i>Rohdea</i> (Indonesia) <i>Schefflera</i> (Malaysia, China) <i>Stephanotis</i> (China) <i>Vitis</i> (F; USA, Chile) <i>Yucca</i> (China) <i>Zantedeschia</i> (New Zealand) other (Taiwan, Malaysia, Indonesia, Sri Lanka, Netherlands, Australia)
* <i>Pseudococcus maritimus</i> (Ehrhorn)	11	NE	no	<i>Citrus</i> (F; USA) <i>Schefflera</i> (Taiwan) <i>Vitis</i> (F; USA)
<i>Pseudococcus</i> sp.	68	-	-	<i>Actinidia</i> (F; Chile) <i>Citrus</i> (F; USA, Chile) <i>Citrus</i> (Thailand) <i>Codiaeum</i> (Indonesia) <i>Dracaena</i> (Malaysia, Philippines, Indonesia) <i>Durio</i> (F; Thailand) <i>Echeveria</i> (Netherlands) <i>Ficus</i> (China) <i>Heteropanax</i> (China) <i>Musa</i> (F; Ecuador, Philippines) <i>Polyscias</i> (Indonesia, Thailand) <i>Radermachera</i> (China) <i>Vitis</i> (F; Chile, USA) other (Thailand, Philippines, Netherlands, Italy, Germany)
* <i>Pseudococcus viburni</i> (Signoret)	38	PA	no	<i>Actinidia</i> (F; Chile) <i>Citrus</i> (F; USA, Chile) <i>Echeveria</i> (Netherlands) <i>Punica</i> (China)

Species	Total Int	Reg Orig	In Kor	Host Genus (Shipment origin)
* <i>Pseudococcus viburni</i> (Signoret)				<i>Vitis</i> (F; Chile) other (Netherlands)
<i>Ripersiella multiporifera</i> Jansen	2	OR	no	<i>Dracaena</i> (Vietnam)
* <i>Spilococcus mamillariae</i> (Bouche)	1	PA	no	undetermined succulent (Indonesia)
* <i>Vryburgia amaryllidis</i> (Bouche)	13	PA	no	<i>Crassula</i> (Germany) <i>Echeveria</i> (Netherlands, USA, Australia) other (Italy, USA, Netherlands, South Africa)
<i>Vryburgia distincta</i> (De Lotto)	1	AF	no	<i>Crassula</i> (Netherlands)
<i>Vryburgia</i> sp.	4	-	-	<i>Echeveria</i> (USA) other (USA)
<i>Vryburgia trionymoides</i> (De Lotto)	12	AF	no	<i>Aeonium</i> (Australia) <i>Crassula</i> (Australia) <i>Echeveria</i> (Japan, USA, Netherlands, Australia, New Zealand) <i>Sedum</i> (Japan) other (USA)

species) and mealybugs (Pseudococcidae; 29 species) constituted the main groups. The other families are each represented by only one or a few species. The ongoing and increasing international trade during the last five years contributed to the discovery of many scale insect species in Korean ports of entry.

Pit scale insects (Asterolecaniidae) mostly occur in the tropical and subtropical regions and are a relatively small family of scale insects with 240 species known worldwide. Damage caused by this family and its importance in quarantine are probably underestimated. Of these, 2 (1%) and 74 (31%) species are known to occur in Korea and Palearctic region (including the Korean Peninsula), respectively (Table 2).

Planchonia stentae (Brain), an Afrotropical species, was intercepted on *Echeveria* from Mexico. This species is reported as a serious pest on variety of host plants (Stumpf and Lambdin, 2006). Its hosts are tropical and subtropical plants that might not establish in the open in Korea given that the Korea is included in the temperate zone; however, it should be considered to survive in the greenhouse on its hosts.

Soft scales (Coccidae) represent an economically important group of insects. Many species attack agricultural, ornamental and greenhouse plantings throughout the world (Hamon and Williams, 1984). They are the third largest family of scale insects with 1,146 species known worldwide, of which 32 species (3%) are known to occur in Korea. Of the 12 species of soft scales that were intercepted, 9 species (75%) are not known

to occur in Korea or to be pest species if introduced to Korea (Tables 2, 3, 6).

Ceroplastes rusci (Linnaeus), a Palearctic species, was intercepted on undetermined tree from Israel once. This species is a polyphagous species (45 plant families) and distributed in all zoogeographical regions except for Australasian and Antarctica regions. It is not known as a pest.

Ceroplastes stellifer (Westwood) was first described on *Cypripedium niveum* from Thailand. This species was intercepted on *Chrysalidocarpus* from Malaysia once at a Korean port of entry. Its host range and distribution are relatively wide and it is considered a potential threat to crops in Florida (Ben-Dov et al., 2012).

Coccus longulus (Douglas), a Palearctic species, was intercepted once on *Ficus* from Malaysia and is not reported to be an economic pest.

Coccus viridis (Green) was first described on coffee from Sri Lanka. This species was found 12 times on *Chrysalidocarpus*, *Jatropha*, *Polyscias*, *Schefflera* and *Zamioculcas* from China, Indonesia, Malaysia and Taiwan in quarantine inspections. The green scale is a serious pest of coffee, citrus and other crops in many tropical areas (Hamon and Williams, 1984). Almost all of its hosts are from subtropical and tropical habitats. Therefore, it is likely to cause concern in greenhouses if this pest is introduced to Korea. Plants used for propagation should be carefully examined for pests since the pest can often survive for

longer periods of time on leaves.

Oriental species, *Milviscutulus mangiferae* (Green) and *Paralecanium expansum* (Green) were intercepted on *Cordyline* from Indonesia once and on *Chrysalidocarpus* from Malaysia once, respectively. They are not reported as pests.

Pulvinaria psidii Maskell was first reported on *Psidium* from Sandwich Islands. This species was intercepted twice on *Coffea* and *Schefflera* from Vietnam and Costa Rica. It is reported to be a pest of mango in Egypt (Nada et al., 1990).

Pulvinariella mesembryantheri (Vallot) is a Palearctic species and was intercepted on *Mesembryanthemum* from Australia once. It is reported as a potential pest to Aizoaceae in California (Ben-Dov et al., 2012).

The black scale, *Saissetia oleae* (Olivier), was intercepted 4 times on *Durio*, *Ficus* and *Olea* from Thailand, Malaysia and the Netherlands at quarantine inspections. It is considered to be a pest of citrus, olives, apricots and other plants in California (Hamon and Williams, 1984; Gill, 1988). 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 area of Korea. Therefore, it is considered a potential threat to plants if introduced into Korea.

False armored scales (Conchaspidae) occurring in all zoogeographic regions are a small family of scale insects with 30 species known worldwide; no species of this family have been reported to occur in Korea (Table 2).

Conchaspis angraeci Cockerell described from Jamaica was intercepted twice on *Codiaeum* from Indonesia and *Schefflera*

from Malaysia. This is the only species of *Conchaspis* that is widely distributed; recently it has been reported as a pest of *Vanilla fragrans* in Reunion (Ben-Dov et al., 2012). It has been introduced accidentally to many tropical countries and seems to be a recent introduction to the tropical South Pacific area (Williams and Watson, 1990).

Armored scales (Diaspididae) occur in every part of the world where plants grow. This family accounts for the largest and there are 2,512 species known worldwide. Of these, 76 species (3%) are known to occur in Korea and 645 species (26%) in the Palearctic region (Table 2). Armored scales between 2007 and 2011 were intercepted 3,904 times; of these, specimens from the Oriental region represented 87% (3406 times) of the interceptions (Tables 3, 4). In terms of host plants, *Musa* (fruits) constitutes 79.6% of the interceptions and it is the most common intercepted host plant followed by citrus fruits at 9.1% (Table 5). Thirty species (57.7%) not known in Korea were intercepted 3,533 times (90.7%) on imported plants (Tables 6, 7).

Abgrallaspis aguacatae Evans, Watson and Miller was described on avocado from Mexico. It is only known to feed on avocado and is not known to cause significant damage to avocados in Mexico (Evans et al., 2009).

Abgrallaspis cyanophylli (Signoret), a Palearctic species, was intercepted 4 times at Korean ports of entry. The cyanophyllum scale is widely distributed in the tropical and subtropical regions. It is highly polyphagous causing damage to various ornamentals (Davidson and Miller, 1990); therefore, it

Table 4. Interceptions (Int.) of main families of scale insects (Coccidae, Diaspididae, and Pseudococcidae) at Korean ports of entry (2007-2011) by seven zoogeographic regions

Region	Coccidae		Diaspididae		Pseudococcidae	
	Total Int.	% / total	Total Int.	% / total	Total Int.	% / total
Afrotropical	2	2.8	5	0.1	4	0
Antarctica	0	0	0	0	0	0
Australasian	2	2.8	72	1.8	30	0.2
Nearctic	0	0	368	9.4	117	0.7
Neotropical	5	7	40	1	281	1.7
Oriental	57	80.3	3,406	87	16,116	97.1
Palearctic	5	7	10	0	44	0.3
Total	71	100	3,904	100	16,592	100

Table 5. Interceptions (Int.) of main families of scale insects (Coccidae, Diaspididae, and Pseudococcidae) at Korean ports of entry (2007-2011) by host plants [F: fruits, L: leaves, cut-flowers, or plants for propagation]

Coccidae			Diaspididae			Pseudococcidae		
Host Genus	Total Int.	%/total	Host Genus	Total Int.	%/total	Host Genus	Total Int.	%/total
<i>Schefflera</i> (L)	10	14.1	<i>Musa</i> (F)	3,108	79.6	<i>Musa</i> (F)	10,951	66
<i>Ficus</i> (L)	9	12.7	<i>Citrus</i> (F)	354	9.1	<i>Ananas</i> (F)	4,730	28.5
<i>Musa</i> (F)	9	12.7	<i>Persea</i> (F)	78	2	<i>Citrus</i> (F)	217	1.3
<i>Citrus</i> (L)	6	8.5	<i>Dracaena</i> (L)	54	1.4	<i>Polyscias</i> (L)	179	1.1
<i>Polyscias</i> (L)	4	5.6	<i>Actinidia</i> (F)	49	1.3	<i>Dracaena</i> (L)	99	0.6
<i>Chrysalidocarpus</i> (L)	3	4.2	<i>Sansevieria</i> (L)	30	0.8	<i>Heteropanax</i> (L)	40	0.2
<i>Citrus</i> (F)	3	4.2	<i>Chrysalidocarpus</i> (L)	25	0.6	<i>Vitis</i> (F)	38	0.2
<i>Zamioculcas</i> (L)	3	4.2	<i>Ananas</i> (F)	23	0.6	<i>Ficus</i> (L)	35	0.2
<i>Skimmaia</i> (L)	2	2.8	<i>Plumeria</i> (L)	21	0.5	<i>Codiaeum</i> (L)	33	0.2
<i>Actinidia</i> (F)	1	1.4	<i>Cycas</i> (L)	17	0.4	<i>Echeveria</i> (L)	33	0.2
Other	21	29.6	Other	145	3.7	Other	237	1.4
Total	71	100	Total	3,904	100	Total	16,592	100

Table 6. Number of species (# sp.) and percent of total number of scale insect species (% sp.) intercepted at Korean ports of entry (2007-2011) by family and their distribution in Korea

Distribution in Korea	Asterolecaniidae	Coccidae	Conchaspidae	Diaspididae	Eriococcidae	Monophlebidae	Pseudococcidae
	# sp./ (% sp.)	# sp./ (% sp.)	# sp./ (% sp.)	# sp./ (% sp.)	# sp./ (% sp.)	# sp./ (% sp.)	# sp./ (% sp.)
Recorded in Korea	1	3	0	12	1	0	5
Found in greenhouse in Korea	50	25	0	23.1	50	0	17.2
Not known in Korea	0	0	0	10	0	0	1
Total # species intercepted	0	0	0	19.2	0	0	3.5
Recorded in Korea	1	9	1	30	1	1	23
Found in greenhouse in Korea	50	75	100	57.7	50	100	79.3
Total # species intercepted	2	12	1	52	2	1	29
Total # species intercepted	100	100	100	100	100	100	100

should be considered a potential threat to Korea.

Aonidiella aurantii (Maskell) was first described on oranges and lemons imported into New Zealand from Australia. This species is a polyphagous species and the most important citrus pest in the world (Miller and Davidson, 2005). The California red scale was intercepted 115 times on *Citrus*, *Dracaena* and *Nerium* from the USA, Australia, Thailand and Malaysia at Korean ports of entry. It has been reported as a pest not only of fruits but also of ornamental plants worldwide. It should be regarded as a potential threat to Korean agriculture since its

major hosts can grow in the open in the southern area of Korea.

The Oriental scale, *Aonidiella orientalis* (Newstead), an Oriental species, was intercepted once on an undetermined cut flower from Malaysia. It is a polyphagous species and has been known as a serious pest of coconut palms and ivy in Florida (Miller and Davidson, 2005).

Aspidiotus excisus Green, the most frequently intercepted species of armored scales, was described on *Cyanotis pilosa* from Sri Lanka. It was intercepted 2,983 times on pineapples (*Ananas*), bananas (*Musa*) and grapes (*Vitis*) fruits from

Table 7. Interceptions of different scale insect species (# int.) and the percent of total number of scale insect species (% sp.) intercepted at Korean ports of entry (2007-2011) by family and their distribution in Korea

Distribution in Korea	Asterolecaniidae	Coccidae	Conchaspidae	Diaspididae	Eriococcidae	Monophlebidae	Pseudococcidae
	# int./ (%) int.	# int./ (%) int.	# int./ (%) int.	# int./ (%) int.	# int./ (%) int.	# int./ (%) int.	# int./ (%) int.
Recorded in Korea	4	43	0	139	1	0	95
Found in greenhouse in Korea	80	64	0	3.6	50	0	0.6
Not known in Korea	0	0	0	221	0	0	389
Total # species intercepted	0	0	0	5.7	0	0	2.4
	1	24	2	3,533	1	1	15,952
	20	36	100	90.7	50	100	97
	5	67	2	3,893	2	1	16,436
	100	100	100	100	100	100	100

Southern Asia and South America. It is considered a pest of ornamental plants (Davidson and Miller, 1990).

Aulacaspis yasumatsui Takagi was first described on *Cycas* from Thailand in the 70s. This species has now spread to many other countries in the world and its effect is quite devastating. The cycad aulacaspis scale was intercepted on *Cycas* from China, Taiwan and the Philippines 13 times. It could pose a threat to Korean native cycads since its outbreaks of the pest have occurred in many countries outside its native range.

The Putnam scale, *Diaspidiotus ancyclus* (Putnam), is a Nearctic species that was intercepted once on a kiwi fruit (*Actinidia*) from New Zealand. It is occasionally an economic pest and can reduce plant vigor on blueberries because of its cryptic habit under the bark of blueberry trees (Miller and Davidson, 2005). In addition, it has been reported as a pest of walnut, elms, other ornamentals and peaches (Gill, 1997). One of its hosts, many nursery trees of *Vaccinium* (Ericaceae) is frequently imported from the USA and Canada into Korea. Therefore, it should be considered as a potential invasive species.

Duplachionaspis divergens (Green) was described on *Andropogon nardus* from Sri Lanka and is only known to occur on grasses (Poaceae). This species was intercepted six times on *Cymbopogon*, not for propagation from Thailand and Cambodia and has been reported as a minor pest of sugarcane in India and Columbia (Evans and Hodges, 2007).

Fiorinia coronata Williams and Watson, an Australasian

origin, was intercepted 4 times on *Chrysalidocarpus*, *Ficus* and an undetermined tree from Malaysia and Thailand. It is not reported as a pest.

Furcaspis biformis (Cockerell), an Afrotropical species, was intercepted on *Pedilanthus* from Indonesia once. The orchid scale is confined to the plant family Orchidaceae and considered to be an occasional pest (Davidson and Miller, 1990).

Hemiberlesia palmae (Cockerell) was described on palms from Jamaica. The tropical palm scale was intercepted 13 times on *Chrysalidocarpus*, *Cordyline* and *Musa* from Malaysia and the Philippines at Korean ports of entry. This species is a pest of crops in the tropics, such as banana, coconut palm, oil palm, manihot and cocoa (Miller and Davidson, 2005).

Hemiberlesia rapax (Comstock), a Palaearctic origin, is polyphagous and has been known as a pest of several crops in tropical and subtropical regions, such as kiwifruit, citrus, olive, mango and tea plant (Ben-Dov et al., 2012). The greedy scale was frequently intercepted at 59 times on actinidia, citrus, cocos, cucurbita, persea and vitis fruits from New Zealand, Chile, the USA and the Philippines.

Howardia biclavis (Comstock), a Nearctic species, occurs in tropical areas throughout the world. It was intercepted 6 times on *Plumeria* from Indonesia and on an undetermined tree from Malaysia. The mining scale is a polyphagous species and also has been reported as a pest of coffee, ornamentals, teas, citrus and macadamia (Miller and Davidson, 2005; Ben-Dov et al., 2012).

Lepidosaphes beckii (Newman), most occurring in subtropical

and tropical regions, was intercepted 123 times on *Citrus* fruits from the USA and Chile, *Dracaena* from Indonesia and China, *Schefflera* from the Philippines and an undetermined tree from Vietnam. The orange scale has been reported as a serious and widespread pest of citrus (Davidson and Miller 1990; Bedford and Cilliers 1994). It should be considered as a potential invasive species because two of its hosts, *Citrus* and *Camellia*, are grown outdoors in Korea. Plants imported for propagation, such as *Dracaena* and *Schefflera* often harbor armored scale pests.

Lepidosaphes chinensis Chamberlin was described on *Magnolia* from China and was intercepted 7 times on *Rhapis* and *Cycas* from China. It is not reported as a pest.

Lepidosaphes laterochitinsa Green, a Palaearctic species, was intercepted 44 times on *Dracaena* from Indonesia, the Philippines, Malaysia and Vietnam. Recently, we found this species occurring on imported *Dracaena* plants growing in a greenhouse in Korea, which was eradicated immediately. It is not reported as a pest; however, *Osmanthus*, *Camellia* and *Eurya* plants are among its known hosts which grow in the open in Korea.

Lepidosaphes tapleyi was described on *Mangifera indica* from Sudan and was intercepted once on a *Cocus* fruit from Malaysia. It is not documented as a pest.

The croton scale, *Lepidosaphes tokionis* (Kuwana), a Palaearctic origin, was intercepted 9 times on *Codiaeum*, *Dracaena* and *Sansevieria* from Sri Lanka, Indonesia and China. Davidson and Miller (1990) listed this species as a pest which hosts include *Cordyline*, *Anthurium*, *Codiaeum*, *Croton*, *Gossypium*, *Citrus* and *Capsicum*. It was found on *Codiaeum* in a greenhouse in Japan, a neighboring country.

Lindingaspis rossi (Maskell), an Australasian and a polyphagous species, was intercepted once on *Leucadendron*, not for propagation, from Australia at a Korean port of entry. It has been considered a pest of *Citrus* in New Zealand, the USA and southern Africa (Ben-Dov et al., 2012).

Melanaspis bromiliae (Leonardi) was described on pineapple from the Canary Islands. The ananas scale was intercepted 13 times on ananas fruits from the Philippines at Korean ports of entry. It has not been reported as a pest.

Morganella longispina (Morgan), a Neotropical origin, was intercepted once on a citrus fruit from the USA. This species has

been reported damage to tea plants in India and grapefruits, lemons and figs in Tahiti (Williams and Watson, 1988; Ben-Dov et al., 2012).

Octaspidiotus stauntoniae (Takahashi) was first described on *Stauntonia obovatifolia* from Taiwan and was intercepted on *Jasminum* from Vietnam once at a Korean port of entry. This species has not been known as a pest.

Parlatoreopsis chinensis (Marlatt), a Chinese origin and a widespread species in China, was intercepted once on *Styphnolobium* from China. The Chinese obscure scale was introduced into the USA from the Old World (Takagi, 1969) and it is considered to be an occasional pest (Davidson and Miller, 1990; Miller and Davidson 2005).

Parlatoria cinerea Hadden was described on *Citrus* and cultivated vine from French Polynesia. The apple parlatoria scale, a tropicopolitan species, was intercepted 3 times on *Citrus* and *Stephanotis* from Thailand and China. This species was listed as a pest in the USA (Davidson and Miller, 1990).

Parlatoria pittospori Maskell, an Australasian species, was intercepted once on a *Paranomus* plant from South Africa. The pittosporum scale was distributed in South Africa, Australia, New Zealand and the USA. It has been reported as a pest of apples in New Zealand and as a minor pest of certain ornamental in California, USA (McKenzie, 1956; Timlin, 1964).

Parlatoria ziziphi (Lucas), the frequently intercepted at Korean ports of entry, was described on *Ziziphus pinnachristi* from France. The black parlatoria scale has long been considered one of the major pests of citrus in certain areas such as China and southeast Asia (Miller and Davidson, 2005). It requires attention because it is listed as a serious and widespread pest (Davidson and Miller, 1990).

Pinnaspis musae Takagi, an Oriental origin, was intercepted 108 times on *Musa* fruits from the Philippines. This species is confined to *Musa* plants and it is not reported as a pest.

Pseudaonidia trilobitiformis (Green), an Oriental and a polyphagous species, was intercepted once on *Ficus* from China. The trilobite scale has been recorded as a pest of cocoa in Congo (Liegeois, 1944). Its hosts also include *Camellia*, *Eurya* and *Thea* that can grow outdoors in the southern area of Korea. It is possible that it may be able to survive in greenhouses if it is introduced into Korea.

Pseudaulacaspis eugeniae (Maskell) was described from

Australia and was intercepted once on a *Xanthorrhoea* plant from Australia. This species has not been known as a pest.

Rolaspis lounsburyi (Cooley), an Afrotropical origin, was intercepted once on *Phyllica* plant, not for propagation, from South Africa. This species is distributed in the Afrotropical region and it has not been reported as a pest.

Unaspis citri (Comstock) was described on *Citrus* from the USA. This species was intercepted once on a citrus fruit from the USA. It has been reported as a serious and widespread pest of citrus (Ben-Dov et al., 2012). Although it is reported that this species is not problem in temperate areas, it deserves attention since citrus is one of economic crops in Korea.

The nine species known only to occur in greenhouses in Korea, *Aspidiotus nerii* Bouche, *Chrysomphalus aonidum* (Linnaeus), *Diaspis boisduvalii* Signoret, *Diaspis bromeliae* (Kerner), *Diaspis echinocacti* (Bouche), *Hemiberlesia lataniae* (Signoret), *Parlatoria proteus* (Curtis), *Pinnaspis buxi* (Bouche) and *Pinnaspis strachani* (Cooley), are regularly intercepted on imported plants. A total of interceptions of these species was 177 times; of these, *C. aonidum*, *D. echinocacti*, *P. proteus*, *P. buxi* and *P. strachani* were usually intercepted on plants for propagation.

Felt scales (Eriococcidae) occur in all zoogeographic regions and are the fourth largest family of scale insects with 668 species known worldwide, of which 14 species (2%) are known to occur in Korea (Table 2).

Acanthococcus coccineus Cockerell, a Nearctic species, was intercepted once on *Echeveria* from Japan. This species has a restricted host range occurring on succulent plants. This species infests cacti which have been transported all over the world by international trade and has become a cosmopolitan species found in nurseries and greenhouses worldwide (Miller and Miller, 1992). It is not reported as a pest; however, recently the quantity of succulents imported into Korea and cultivated in greenhouses has increased dramatically. Therefore, imported succulents should be carefully examined for the presence of this species.

Giant scales (Monophlebidae) were part of the family Margarodidae until recently. Currently, it is comprised of 239 species with 5 species (2%) of the species known to occur in Korea (Table 2).

Icerya seychellarum (Westwood), an Afrotropical and a

polyphagous species, was intercepted on an undetermined tree from China once. This is a common pest on various host plants in parts of Asia, several Pacific islands, Japan and Africa (Ben-Dov et al, 2012).

Mealybugs (Pseudococcidae) include many species of economic importance and are the second largest family of scale insects with 2,247 species known worldwide. Of these, 44 species (2%) are known to occur in Korea and 710 species (32%) in the Palearctic region. Between 2007 and 2011, mealybugs were intercepted 16,592 times; of these, 97.1% of the interceptions (16,116 times) were from the Oriental region followed by the Neotropical region which accounted for 1.7% of the interceptions (Tables 2, 3, 4). In terms of host plants, bananas (*Musa*) and pineapples (*Ananas*) fruits constitute 94.5% of the interceptions and are the most common intercepted host plants (Table 5). Twenty-three species (79.3%) not known in Korea were intercepted 15,952 times (97%) on imported fruits and plants (Tables 6, 7).

Dysmicoccus brevipes (Cockerell) is known as an important pest of pineapples worldwide. It was intercepted 4,763 times at Korean ports of entry; almost all of the interceptions were on ananas fruits from the Philippines (4,688 times). The pineapple mealybug is a polyphagous species and primarily occurs in the subtropical and tropical regions. This species is a target species for biological control in the Pacific area and southern Asia (Williams, 2004).

Dysmicoccus neobrevipes Beardsley, a common species in southern Asia, is a polyphagous species that is probably native to the Australasian region. This species was intercepted 10,936 times which were almost all taken in quarantine inspections on musa fruits from the Philippines. There is a recent report that this species causes die back in new shoots of *Albizia saman* in Thailand (Williams, 2004).

Ferrisia virgata (Cockerell) was described on an undetermined grass from Jamaica. It was intercepted 10 times on import fruits and ornamentals. This widespread and polyphagous species is known as a serious pest of cotton in India, where it also attacks *Annona* species and *Psidium guajava* and is a minor pest of *Piper nigrum*. In Bangladesh, it is known as a pest of *Corchorus olitorius*, causing the formation of barkly fibre (Williams, 2004). The striped mealybug is one of the mealybug vectors of "swollen shoot" virus disease of cacao in West Africa (Ben-Dov

et al., 2012). Its hosts include several economic species.

Maconellicoccus hirsutus (Green) is an Oriental species that was intercepted 5 times on *Areca* from China, *Ficus* from Vietnam and China and a musa fruit from the Philippines. The pink hibiscus mealybug has been reported as one of the most important polyphagous mealybugs in southern Asia, especially in India (Williams, 2004). This species has invaded the US Virgin Islands, Puerto Rico, St. Kitts, Trinidad, Tobago, Grenada and several other Caribbean islands, where it is damaging coffee, cotton, soybeans, citrus and some other crops (Ben-Dov et al., 2012).

Neotrionymus monstata Borchsenius was described on *Phragmites* from Tadjikistan. This species was taken once at quarantine inspection on *Arundo* from China. It is not recorded as a pest.

Nipaecoccus viridis (Newstead), an Oriental species, was intercepted 3 times on citrus leaves from Thailand. This polyphagous mealybug is common throughout southern Asia and usually occurs in the subtropical and tropical regions. When first introduced into Jordan in 1993 in the absence of its natural enemies, infestations of this species sometimes resulted in total loss of the citrus crop. In South Africa, it is a major pest of citrus and in Okinawa it is one of the principal pests of mango (Williams, 2004). Therefore, it is likely to cause attention in the greenhouse on its hosts if this pest is introduced to Korea.

Phenacoccus madeirensis Green was intercepted twice on *Ocimum* leaves from China and on an undetermined tree from Ecuador. It is extremely common in Africa where it probably had been introduced from the Neotropical region (Williams and Granara de Willink, 1992). There is a recent report that this species causes damages to leaves of other plants in Japan (Williams, 2004).

Phenacoccus solani Ferris, a Nearctic origin, was taken 15 times in quarantine inspections on imported succulents. This species is a cosmopolitan and a polyphagous pest that often seriously damages host plants (Mazzeo et al., 2008).

Phenacoccus solenopsis Tinsley, a Nearctic and a polyphagous species, was intercepted 5 times on ananas fruits (Philippines), *Euphorbia* (Vietnam), *Ficus* (China) and *Polyscias* (Philippines) plants and on an undetermined tree (Thailand), imported into Korea.

Planococcus ficus (Signoret), a Palearctic origin, was

intercepted 4 times on vitis fruits from the USA. This species has been reported as a pest of grapevine in the Mediterranean region, South Africa, Pakistan and Argentina (Ben-Dov, 1994).

Planococcus lilacinus (Cockerell) was described on a cultivated orange from the Philippines. This species was intercepted on *Dimocarpus*, *Ficus* and *Philodendron* from China. It is a pest of cocoa throughout the Oriental region and also occurs on wide variety of economically important crops such as citrus, guava, coffee, custard apple and mango (Williams, 2004; Ben-Dov et al., 2012).

Planococcus minor (Maskell), an Afrotropical and a polyphagous species, was intercepted 53 times on ornamental plants and tropical fruits from the southern Asia. The Pacific mealybug is a common species of many economically important plants, particularly cocoa, throughout its geographical range (Ben-Dov et al., 2012).

Pseudococcus baliteus Lit was first described on *Ficus elastica* from the Philippines. It was intercepted once on *Polyscias* from Indonesia. It is not reported as a pest.

Pseudococcus calceolariae (Maskell), an Australasian species, was intercepted 38 times on citrus and vitis fruits from Chile, Australia and the USA and on *Protea* from South Africa. The citrophilus mealybug is a highly polyphagous species, reported as a citrus pest in California, Chile, Italy and Crimea (Ben-Dov et al., 2012).

Pseudococcus elisae Borchsenius was described on banana spurs from Colombia. This species was intercepted 12 times on *Codiaeum* (Thailand), *Dracaena* (Costa Rica), *Nerium* (Thailand) and *Polyscias* (Indonesia, Costa Rica) and *Musa* fruits (Colombia, Mexico). It is reported as a common and a polyphagous mealybug in the Neotropical region attacking many cultivated plants (Williams and Granara de Willink, 1992; Ben-Dov et al., 2012).

Pseudococcus jackbeardsleyi Gimpel and Miller, a Nearctic and a polyphagous species, was intercepted 21 times on ornamental plants. This species has been most commonly collected on bananas, tomatoes, potatoes, peppers and hibiscus plants (Gimpel and Miller, 1996).

Pseudococcus longispinus (Targioni-Tozzetti) was frequently intercepted (389 times) at Korean ports of entry. It has a large host range and is a frequent pest of ornamentals outdoors and in greenhouses. The long tailed mealybug primarily occurs in the

tropical and subtropical regions and also in greenhouses in temperate zones. Although this species has been collected on imported ornamental plants in greenhouses in Korea (Han et al., 2002; Kwon et al., 2003), it has been eradicated from these localities.

Pseudococcus maritimus (Ehrhorn), a Nearctic and polyphagous species, was intercepted 11 times on *Citrus* and *Vitis* fruits from the USA and on *Schefflera* from Taiwan. It has been reported in California mainly as a pest of grape, pear and apricot (Godfrey et al., 2002; Ben-Dov et al., 2012).

Pseudococcus viburni (Signoret) was described on *Laurus indicus* from France. The obscure mealybug was intercepted 38 times and is frequently found on *Vitis*, *Actinidia* and *Citrus* fruits. This species is a common and a polyphagous species occurring throughout the tropical and temperate areas. Its hosts include economic importance plants and also it has the cryptic habit of living on roots (Williams, 2004).

Riparsiella multiporifera Jansen, an Oriental species, was recently intercepted on *Dracaena* plants from Vietnam. It may have been overlooked owing to its living on roots. It has not been reported as a pest.

Spilococcus mamillariae (Bouche) was described on roots of *Mammillaria* from England. It was intercepted once on an undetermined succulent from Indonesia. This species is a common pest of ornamental succulent plants (Marotta, 1992; Ben-Dov et al., 2012).

Three species belonging to *Vryburgia*, *V. amaryllidis* (Bouche), *V. distincta* (De Lotto) and *V. trionymoides* (De Lotto) were intercepted (26 times) on various succulent plants. Of these, *V. amaryllidis* (Bouche) is an important pest in greenhouse and plant nurseries (Williams, 2004).

A total of 113 species of scale insects in 7 families were intercepted during the period of 2007 to 2011. Of these, 43 species are considered as potential invasive species to Korea. Although many of them are of potential economic importance, some perhaps would not pose a threat to Korean agriculture since they are native to subtropical and tropical habitats and the Korean climate may not be appropriate for them. However, some of them may pose a threat since they are usually found on imported plants of economic importance and may make their way into the Korean environment, either in greenhouses or outdoor setting. Furthermore, the current Korean weather

conditions are changing towards becoming warmer and numerous imported subtropical and tropical crops are being grown in greenhouses in the southern area including Jeju. Scale insects reported as invasive pests in Korea are sometimes recognized until their populations have exploded to the point where they cause economic damage to plants. Species are most often introduced and established into the region through plants imported for propagation. Therefore, preventive measures are required to overcome this challenge. The most effective approach to block the introduction of an invasive species is to regularly update a list of pests intercepted on imported plants, list potential invasive species by analyzing information on intercepted pests and keep them under constant surveillance. Also researchers and inspectors related to quarantine works need to be aware of which species occur in Korea and which species are being intercepted on imported plants at Korean ports of entry.

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