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# Pest risk assessment of insects in sea cargo containers

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**Abstract** A survey of the floors of 3001 empty sea cargo containers in storage was undertaken to estimate the quarantine risk of importing exotic insect pests into Australia, with special reference to pests of timber. More than 7400 live and dead insects were collected from 1174 containers. No live infestations of timber-feeding insects were recorded, but feeding damage detected in one floor indicates a low risk of importing colonies of timber pests in containers. The survey collection of dead insects demonstrates that containers are regularly exposed to economically important quarantinable insects, including timber pests (bostrichids, curculionids, cerambycids, siricids and termites), agricultural pests (including *Adoretus sinicus, Adoretus* sp., *Carpophilus obsoletus* and *Philaenus spumarius*), and nuisance pests (vespids and *Solenopsis* sp.). Stored product pests were found in more than 10% of containers. The assessment of pest risk associated with shipping containers is discussed in terms of the quantity and quality of opportunities for exotic insects to establish via this pathway.

Key words pest risk analysis, quarantine, shipping containers, timber pests.

## INTRODUCTION

One of Australia's great natural advantages with respect to quarantine and the introduction of pest species has been its relative isolation. The importance of preventing entry of potential pest species was recognised early in the formation of the Australian Quarantine and Inspection Service (AQIS). Although many deliberately and accidentally introduced species have become pests, many potential pest species have yet to establish in Australia, either by chance or design. Quarantine Proclamations (1998) of the Quarantine Act (1908) (the regulations that govern quarantine in Australia) cover a very broad range of insect and pathogen pests. The threat that these species pose to our biosecurity, if introduced, has rarely been estimated. Part of that assessment is to ascertain the likely pathways of introduction, and to determine just how many insects arrive by various means.

With the adoption of the General Agreement on Tariffs and Trade (GATT) in the Uruguay round of negotiations in 1993, a fundamental change occurred in the discipline of plant quarantine and its administration. The prime purpose of the GATT negotiations was the reduction of tariff barriers and, in recognition that technical barriers to trade may be erected where others had been removed, the GATT included an agreement on Sanitary and Phytosanitary matters (the SPS Agreement). The drawing up of import restrictions in the context of liberalisation of trade has led to quarantine considerations becoming of major significance. Essentially the SPS agreement recognised that technically formulated restrictions on the movement of commodities were justified, but that the systems should operate within a set of standards. A country that formulated import restrictions according to these standards would not be challenged under the GATT (now the World Trade Organisation (WTO)).

The GATT recognised that it did not have the technical expertise to set plant quarantine standards and indicated that the International Plant Protection Convention (IPPC) should be the body to set international standards in relation to phytosanitary matters. Since 1992 the IPPC Secretariat located within the Plant Protection Service, Food and Agriculture Organization (FAO) Rome, has administered a standard setting procedure based on a system of Technical Working Groups, consultation with regional plant protection organisations, government consultation and final international adoption through the FAO Conference system.

The IPPC is based on the principles of scientifically justifiable and transparent quarantine measures. The convention also incorporates the principle of necessity. The present paper shows that the wooden components of sea cargo containers are constantly exposed to timber-infesting insects from many sources, not the least being from dunnage (lowgrade timber used for packing and stabilising goods). There is a necessity to preclude the container wooden components from infestation because they can be in service for many years. The requirement for all wooden components of cargo

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containers entering Australia to be treated has not been previously reviewed.

Approximately 25 years ago, when sea cargo containers were mostly composed of wooden material, AQIS introduced a requirement that wooden components of cargo containers had to be either registered as permanently treated to AQIS standards or inspected every time that container was landed in Australia. Inspection required the container to be stopped, fully unloaded and approved free of pests prior to release regardless of whether the cargo was of quarantine concern or not. By 1995 more than 5 million containers were registered as treated to AQIS's standards.

In more recent years cargo containers have been built mainly of steel with plywood or timber floors (dry boxes). This reduction in risk has been offset by a significant increase in the amount of container traffic, which has made it almost impossible to detect unregistered containers entering Australia. In 1996 approximately 770 000 shipping containers entered Australian ports, 88% of which were designated as dry boxes. Containers that had approved floor treatments registered with AQIS were considered to be low risk and given immediate FCL (full container lot) release. Containers without floor treatments registered with AQIS were considered to be untreated. Although most of these containers had some floor treatment applied, the quality of the treatment was not guaranteed by the container owners, which placed them in a high-risk category. Previously there has been no assessment of what sort of quarantine risk is in fact posed by dry boxes entering Australia. The outcome of this review is that AQIS requires treatment of wooden components of sea cargo containers (to the standard set by AQIS), but the treated containers are no longer required to be registered. Verifications will be carried out by random inspection of containers and sampling with analysis of the wooden components.

A report into quarantine in Australia was carried out by Nairn *et al.* (1996). The outcomes of the container review coincide with the recommendations of that report. The report emphasised issues such as the continuum of quarantine (preborder, border and post-border) methods. The treatment of wooden components keeps the risk of infestation offshore, and minimises the risk of the container floors carrying timber-infesting insects into Australia as well as facilitating speedy movement of cargo because the containers themselves are not stopped to be inspected.

Here, we assess the probability of importing harmful exotic insects in the floors of containers by undertaking a survey of imported dry boxes. Incidental to the original purpose of the review to investigate infestations or potential infestations of timber insects in the wooden components of containers, large numbers of non-timber-infesting insects were found both live and dead. These were also identified and are included in the present report.

### METHODS

After destuffing, containers are stored until they are required. The turnaround time for a container can vary from a few days to a few months. Our survey was carried out at nine container parks around Brisbane from 28 February 1996 to 20 August 1996. We inspected 2500 unregistered and 501 registered containers of unknown origin. Both 6-m and 12-m containers were inspected. The time spent searching the floors of each 6-m container ranged from approximately 3 min for a washed plywood floor, to 30 min for containers with residual material and large numbers of insects. The time taken to inspect 12-m containers was approximately double that for a 6-m container.

We used a torch to search the wooden components of containers for timber insects, bore holes, timber damage and frass. All holes in the timber were inspected thoroughly and excavated for signs of current insect activity. All insects collected (including non-timber insects) were identified to order or family, and preserved in 80% ethanol before being sent for further identification to the Biological and Chemical Research Institute (BCRI) in New South Wales (NSW) at Rydalmere. The full collection of insects that arrived intact was mounted and is now housed at the Orange Agricultural Institute.

Containers may be stored for extended periods and many insects were in poor condition due to predation and decay. Specimens that were unlikely to be identified to a useful level were not collected unless they were from groups that posed a high risk to timber, such as the Isoptera, Siricidae, Bostrichidae and Cerambycidae. Although we aimed to collect all insects from every container, the diminishing returns of insects collected for the amount of time spent searching made this untenable. A proportion of small insects (< 2 mm) are likely to have been missed, as well as some insects that are likely to be found in crevices in wood. On a few occasions, containers with large amounts of organic residue carried hundreds of dead insects. When it was not feasible to collect all individuals, representatives of each species encountered were taken and a count or an estimate was made of total numbers. If large numbers of live insects were encountered, the container was swept clean and all living insects were removed and preserved.

### RESULTS

#### **Description of the collection**

A total of 7861 arthropods was recorded from the interior of containers sampled. The majority (7426) were adult or immature insects, or remnants of insects (wings, pupal cases, etc.). Insects were found in 1174 (39%) of the 3001 containers inspected. Live insects accounted for 19% (1339) of the total, and were found in 176 containers (6%). Approximately half of the live insects were immatures. The collection encompasses 18 insect orders and at least 114 families. Most of the taxa identified to species or genus were detected in only one or two containers (Fig. 1).

Other groups collected were spiders (72), isopods (39), mites (25), millipedes (16), centipedes (3), scorpions (3) and



*Fig. 1.* Total number of  $(\bigcirc)$  distinct insect taxa identified to genus and species, and  $(\blacktriangle)$  total number of all exotic insect groupings found in each container frequency class. *Tribolium castaneum*, which was found in 248 containers, is not included in the figure.

ticks (1). Three exotic isopods from the genus *Oniscus* (Oniscidae) were found in one container. The great majority of the 271 specimens that were not identified to class are likely to be of insect origin.

Due to the poor quality of some of the material, approximately 10% of the insects (773) broke up in transit from Brisbane to Rydalmere and were neither mounted nor identified. An inventory of the insects collected is included in Appendix I, and there is still an opportunity to identify many of the specimens further.

## **Timber pests**

No live exotic timber-feeding insects, or signs of active timber infestations, were found in the wooden floors of any containers in our survey. Assuming that the containers surveyed constitute a random sample, the probability of encountering no live infestations for a given proportion of infested containers (P) will follow a binomial distribution:

$$P[X = x] = \begin{vmatrix} n \\ p^{x}(1-p)^{n-x} \\ x \end{vmatrix}$$
 where:

n is the number of containers inspected, x is the number of containers found containing an infestation and p is the actual proportion of all containers infested.

For our purposes, we need to calculate the probability (*P*) of finding no infested containers (x = 0) in 2500 (*n*). The equation reduces to

$$P[X = 0] = (1 - p)^{2500}$$

Considering only unregistered containers, there is a 95% probability that we would encounter an infestation if the proportion of infested containers was greater than 1 in 835. At the current rate of 230 000 unregistered containers imported annually, we estimate that less than 300 of these would contain live insect infestations in their timber components.

Although no live infestations were detected, feeding damage to a plywood floor was found in one unregistered container that had been fumigated with methyl bromide in Kuala Lumpur, Malaysia, 1 month earlier. Parts of the bostrichid beetle, *Xylothrips religiosus* (Boisduval), were found in the holes that extended through the first ply of wood but stopped at the first line of glue and were shallow enough to leave the beetles exposed to physical damage. The floor treatment listed on the approval plate of this container (Celcure A) was unsuitable for the treatment of plywood floors. Chemical analysis of the floor material, carried out by the Queensland Department of Primary Industries Forestry Branch, indicated that the floor had been treated to very low levels of copper (0.006%), chromium (0.001%) and arsenic (0.003%). These levels are well below the standard required by AQIS.

Insects that have the potential to infest timber were found in 104 (3.5%) of the containers inspected and 15% of these containers had more than one species of timber pest (Table 1). Only one of these was found alive, an unidentified weevil from the subfamily Scolytinae, which was well represented in the survey. Although no infestations were found in the floors of containers, 45 dead insects that are timber pests of quarantine concern were discovered on the floors of shipping containers. The bostrichids *Heterobostrychus aequalis* (Waterhouse) and *Sinoxylon anale* Lesne were the most commonly encountered species that were fully identified. The large number of termites (87) found in 28 containers may include some exotic species.

## Quarantinable insects and stored-product pests

Excluding timber pests, 79 insects from exotic taxa were found in 50 containers (Table 2). Only one live exotic insect was found, the lathridiid beetle *Aridius nodifer* (Westwood), a fungus feeder not considered to be of economic importance.

A number of exotic pest species that are aggressive colonisers were recovered from containers. The most significant agricultural pests collected were *Adoretus sinicus* Burmeister, *Adoretus* sp., *Carpophilus obsoletus* Erichson, *Exitianus indicus* (Distant) and *Philaenus spumarius* Linnaeus. Nuisance pests included several species of Vespidae and an unidentified species of *Solenopsis*.

Pests of stored products were found in at least 333 containers and live insects were found in 20% of these containers. The number is likely to be higher considering that many of the immature insects could not be identified to species. At least 49 of these containers (15%) were infested with more than one species of stored product pest. The most frequently found insects in the survey were the cosmopolitan stored product pests, *Tribolium castaneum* Herbst, *Dermestes maculatus* De Geer, *Lasioderma serricorne* (Fabricius), *Necrobia rufipes* (De Geer) and *Oryzaephilus mercator* Fauvel. These were often associated with residual foodstuffs, mostly cereals, that had not been cleaned from containers.

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## Table 1 Timber pests and potential timber pests taken from containers

		No. insects		
Order/Family	Species	(containers)	Pest status	Hosts and other information
Coleoptera	An abien and statem	1 (1)	Socious timbor post	Doot of nine timber in couthern Australian states
Postrichidae	Dinodomus minutus	1(1) 15(2)	Mainly stored products post	Hosts (hamboo maiza rica driad aassava)
Bostrichidae	Dinoaerus minutus	15(2) 17(10)	Rest of soosoned timber	Hosts (bamboo, maize, fice, dfied cassava)
	Helerobosirychus dequalis*	17 (10)	Pest of seasoned timber	mosts (ratial, reeds, Koompassia malagearensis, rubbar wood). Considered to
				be an exotic species of concern Limited
				establishment in Australia Commonly
				intercepted by quarantine in timber products
	Lyctus brunneus	7 (6)	Serious timber pest	Hosts (karri and jarrah, <i>Agathis</i> , seasoned
	<u>, , , , , , , , , , , , , , , , , , , </u>		r	timbers, plywood, hardwoods)
	Lyctus sp.	1(1)	Serious timber pests	
	Minthea rugicollis	4 (4)	Serious timber pest	Hosts (building and furniture timbers, cotton
				stalks, reeds)
	Sinoxylon anale*	8 (6)	Timber pest	Hosts (Dalbergia sissoo, Acacia tortillis, fuel
				wood, Delonix regia, cashew wood, rubber
				wood)
	Unknown sp.	4 (3)	Serious timber pests	
	<i>Xylopsocus</i> sp.	2(2)	Minor pests of logs	Hosts (Endospermum peltatum)
	Ayloinrips religiosus	5(1)	Occasional pest	nosts (seasoned timber). Occasional serious
	Yulothring sp	1(1)	Pests of logs	pest in dead nees in Fapua New Ouniea
Cerambycidae	Arhopalus sp.*	7(4)	Serious pests	A rusticus A tristis and A syriacus are pests
Cerambyerdae	Intoputus sp.	7 (4)	Serious pests	of Pinus spp
	Aromia moschata*	2(1)	Minor pest	Hosts (willow)
	<i>Clytus</i> sp.	1(1)	Minor pest of trees	
	Phoracantha semipunctata	2 (2)	Serious pest of trees	Hosts (many eucalypt species). Still colonising
	_		-	countries establishing Eucalyptus plantations
	Phoracantha sp.	1(1)	Serious pest	Hosts (eucalypts). P. semipunctata is the major
				pest but P. recurva can also cause serious
				damage
	Tetropium castaneum*	1(1)	Serious timber pest	Hosts (spruce ( <i>Picea abies</i> ), conifers, larch)
	Unknown sp.	16 (13)	Serious timber pests	
Curculionidae	(Scolytinae) unknown sp.	24 (15)	Many serious pests	E forminaturic o maior past of too but has
	<i>Euwauacea</i> sp.	20(3)	One minor umber pest	<i>E. formicalus</i> is a major pest of tea but has
				plantations of <i>Gmeling arboreg</i> and
				Paraserianthes falcataria in India
	Hypothenemus sp.	1(1)	One major, some minor pests	<i>H. hampei</i> (coffee, macadamia); <i>H. obscurus</i>
			5 / 1	(macadamia, acacia wood, rubber);
				H. areccae (fruit crops); H. birmanus and
				H. sundaensis (Sapodilla)
	Ips grandicollis	10(1)	Major pest of trees	Hosts (Pinus radiata and P. pinaster).
				Introduced to Australia, SA 1943, WA 1952,
				Eastern States 1980–85
	<i>Xyleborus</i> sp.	16 (4)	Many pests of trees and logs	X. dispar (Crataegus and Sorbus); X. perforans
				(logs); X. affinis, X. spinulosus and X. ferru-
				gineus (tropical pines); X. lecontei (coffee);
Platypodidae	Platynus parallalus	3 (2)	Pasts of recently killed trees	A. <i>barbatus</i> and A. <i>metacuneolus</i> (shade trees) Borers of trunks and large branches of recently
Tatypouldae	T tarypus paratietus	5(2)	Tests of feeling kined fees	killed trees and may cause economic
				damage to unmilled logs or standing dead
				timber. First recorded in Queensland 1968
	Unknown sp	8 (2)	Minor timber pests	
	Chikhown sp.	0(2)	Winor univer pests	
Hymenoptera		<i>( (</i> <b>)</b> )		
Formicidae	Camponotus sp.	6(1)	Serious timber pests	II ( (D' 'I ('))
Siricidae	Sirex juvencus*	3(2)	Potential major pest	Hosts ( <i>Pinus</i> spp., silver fir)
	Orocerus gigas	1(1)	Potentiai major pest	attacked by <i>U</i> aigas which introduces a san
				wood decay fungus. Amylostereum chailletii
	Unocomus on *	2(2)	Potential major rest	
	Otocerus sp.*	2(2)	rotentiai major pest	
Isoptera				
Kalotermitidae	Unknown sp.*	4 (1)	Major timber pests	
Rhinotermitidae	Coptotermes sp.	20(1)	Major timber pests	
Rhinotermitidae	Unknown sp.	45 (15)	Major timber pests	
Unknown	Unknown sp.	18(11)	Many serious timber pests	

\*Insects known to be exotic or of quarantine concern.

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Order/Family	Species	No. insects (containers)	Pest status	Hosts and other information
Blattodea				
Blattidae	Unknown sp.	1 (1)		
Coleoptera				
Brentidae	Baryrhynchus sp.	1 (1)		
Coccinellidae	Adalia bipunctata	4 (4)		Insect predator
	Coccinella septempunctata	2(1)		Insect predator
Cryptophagidae	Cryptophagus yarus	1(1) 1(1)	Minor stored product pasts	
Curculionidae	Unknown sp	1(1) 1(1)	winor stored product pests	
Dermestidae	Trogoderma megatomoides	4(1)		
Lathridiidae	Aridius nodifer	9 (5)		Fungus feeder
Lummunduv	Thes bergrothi	1(1)		I dinguo rector
Nitidulidae	Carpophilus obsoletus	1 (1)	Stored product pest	Hosts ( <i>Phoenix dactylifera</i> , figs, garlic, <i>Litchi chinensis</i> , maize, onions)
Scarabaeidae	Adoretus sinicus	2 (1)	Major agricultural pest	Larvae attack the roots of over 255 plant species including: apples, ginger, maize, <i>Phaseolus</i> <i>vulgaris, Pinus strobus</i> , raspberries, roses, snap beans, strawberries, turf. An unsuccessful biological control program was carried out against this species in Hawaii
	Adoretus sp.	1 (1)	Includes major agricultural pests	Adoretus spp. are serious quarantine threats. A. versutus Harold has been recently been introduced to various Pacific islands. A. fusculus Fåhraeus (sugarcane), A. ictericus Burmeister (pineapple), A. testaceus Hope (rice) and A. versutus (cocoa, Hibiscus tiliaceus)
Silvanidae	Silvanus platanus	4(1)	Minor stored product pests	Distribution limited to Canada, Northern Russia
Tenebrionidae	Unknown sp.	2 (2)		
Trogositidae	Lophocateres pusillus	2 (2)	Minor stored product pests	
		- (-)		
Aphrophoridae	Philaenus spumarius	1 (1)	Occasional pest	Hosts (Eucalyptus?, lucerne, Anaphalis margaritacea, grasses, Cirsium arvense, Calluna vulgaris). Introduced to New Zealand 1960
Cicadellidae	Arawa sp.	1(1)		
	Exitianus indicus	1(1)	Occasional pest	Wide range of economically important hosts
Delphacidae	<i>Toya</i> sp.	7 (1)	Includes some pest species	<i>Toya propinqua</i> (Fieber) is a widespread species recorded as a pest of bermudagrass, cotton and oats. Other species recorded as pests
Flatidae	Unknown sp.	1(1)		
<b>TI</b>	×.			
Chrysididae	Chrysis ignita	1 (1)		
Formicidae	Anoplolepis sp.	2 (1)	Potential pest	A. longipes (Jerdon) and A. custodiens F. Smith, are predatory ants that have been recorded as pests as well as biocontrol agents
	Cardiocondyla sp.	1(1)		r in the sound in agents
	Ectatomma sp.	1 (1)		
	Odontomachus sp.	1(1)		
	Solenopsis sp.	1 (1)	Serious nuisance pests	S. invicta Buren and S. richteri Forel, are targets of intensive control programs in the USA
Ichneumonidae	Rhyssa persuasoria	1 (1)	Beneficial predator	Parasitoid released unsuccessfully in Australia for the control of <i>Sirex noctilio</i> Fabricius
Megachilidae	Unknown sp.	1 (1)		
Vespidae	Polistes gallicus	3 (3)	Nuisance pest	
	Vespula austriaca	1(1)	Nuisance pest	
	Vespula rufa	1(1)	Nuisance pest	
	<i>Vespula</i> sp.	2 (2)	Nuisance pests	Species of Vespula are aggressive colonisers
Lepidoptera				
Lycaenidae	Jamides sp.	1(1)	Some minor pests	J. alecto (Felder) is a minor pest of cardamom
Nymphalidae	Nymphalis milberti	1 (1)	<b>r</b> · · · · ·	
Sphingidae	<i>Deilephila</i> sp.	1 (1)	Some minor pests	D. elpenor (L.) is a minor pest of Pinella ternata and other herbs and D. nerii (L.) is a pest of oleander and closely related plants

# DISCUSSION

Insects found in the present survey include species that pose a threat to Australian agriculture, forestry and amenity. The number of containers searched represents the equivalent of less than 2 days of container imports for Australia. Quarantine pest risk assessment deals with the likelihood of rare events occurring and, despite surveying 3001 containers, we are likely to have encountered only a small fraction of the range of insect species that are associated with containers. From biodiversity studies we would expect that the frequency of insect species found would resemble a log-normal distribution. That is, that most species would be found in a very low proportion of containers while a relatively few species would be found in a high proportion of containers. If the present survey had yielded a large proportion of the total insect fauna associated with containers, we would not expect the overwhelming predominance of insect species found only in single containers. Low interception rates prevent us from quantitatively assessing the risk posed by individual taxa, a problem common to most quarantine pest risk assessments (Nunn 1997). The data taken together, however, indicate the scale at which risk assessment via this pathway needs to be investigated.

Analysis of timber floors as a pathway for the introduction of exotics can be examined directly by the presence of active infestations, and indirectly by the determination of container contents susceptibility and the exposure rate of floors to species of quarantine concern. The proportion of containers imported with active infestations of exotic timber pest in their floors is extremely low. Considering the high volume of container traffic and the frequency with which containers come into contact with potentially serious timber pests, the risk associated with untreated wooden components is not negligible. Although many species of wood-boring insects are unable to be detected until they emerge (Wylie & Yule 1977), the lack of apparent damage to the floors of containers suggests that the timber pests collected are more likely to be associated with the cargo carried in containers, particularly timber dunnage, rather than the floors themselves. Introductions of exotic timber pests are known in dunnage (Ciesla 1993), so it is essential that dunnage is removed from containers and destroyed regardless of the treatment applied.

The only species found attacking container floors, *Xylothrips religiosus* (Boisduval), is recorded from northern Australia, Melanesia, Indonesia and the tropical Pacific (Fisher 1950) and the Malayan Peninsula, and is not considered a serious quarantine concern. It has been intercepted by NSW quarantine twice in shipments of hardwood from New Guinea and Melanesia in the 1950s (Chadwick & Nitikin 1968), and has been recorded from shipments entering through the Port of Brisbane from 1969 to 1976 (Wylie & Yule 1977) and from 1977 to 1985 (Wylie & Peters 1987). Detection of this beetle indicates that floors of containers are susceptible to attack by insects if they are improperly treated.

Most of the timber insects identified to species level are known from Australian records, although several have established only in the last 50 years. *Heterobostrychus aequalis* 

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and *S. anale* have been found in localised colonies in Australia and are of quarantine concern, although they are not quarantinable because they are not subject to official control (AQIS 1992; Brenton Peters, QDPI Forestry, pers. comm. 1997). Several of the exotic timber species collected are known from quarantine collections. For instance, the siricids *Urocerus* spp. have been intercepted by quarantine in NSW (Chadwick & Nitikin 1969) and the Port of Brisbane (Wylie & Peters 1987). A number of potential timber pests were unable to be identified to species and it is likely that some of these are exotic. Of special note are the Bostrichidae, Cerambycidae, Scolytinae and a large number of Isoptera.

Many of the exotic species found are considered to be innocuous, although some serious quarantinable pests were collected that have recently established in Pacific countries. Two specimens of Chinese rose beetles, A. sinicus, were collected, as well as another beetle identified to the same genus. An unsuccessful biological control program was carried out against A. sinicus in Hawaii, while other Adoretus spp. have recently been introduced to various Pacific islands (Beardsley 1993; Tsutsumi et al. 1993). Philaenus spumarius Linnaeus is another pest coloniser that was introduced into New Zealand (Hamilton & Morales 1992). Vespidae are mainly nuisance pests, although Vespula vulgaris (Linnaeus), which has established recently in Australia, reduces honey production through hive robbing and competition (Clapperton et al. 1989). Many species in this family are aggressive colonisers and their prevalence in shipping containers suggests this as a possible pathway for their arrival in Australia.

Organic residues were found in many of the containers which may have attracted and supported insect colonies, especially stored product pests. Containers that harbour infestations of local insects may threaten Australia's international quarantine relationships when they are exported. For example, the cerambycid Phoracantha semipunctata (Fabricius) has breached quarantine in countries with established eucalypt plantations and become a significant pest (Ciesla 1993). Maintaining container cleanliness will reduce the likelihood of exporting quarantine threats, as well as reduce the potential for colonies of exotic species or strains to increase in size and establish. There is a need to shift the onus for pest risk management onto commercial operators. Interception of pests by quarantine inspectors on high volume commodities cannot be expected to act as a significant barrier to pest establishment, where the proportion of exotics detected can only ever be a small fraction of those imported. Despite low interception rates, containers that pose a high quarantine risk must be identified for inspection to ensure that treatments comply with Australian quarantine standards.

The quantity of other exotic insects found in containers, including some major agricultural pests and aggressive colonisers, establishes that this is a pest risk pathway that warrants attention. To further quantify the risk, we need to experimentally determine the proportion of quarantinable insects that arrive alive, and whether deaths en route can be attributed to transport conditions, quarantine treatments, storage conditions or predation. Quantifying establishment potential of newly arrived exotics after they disperse in search of resources

is problematic and carries the most uncertainty in virtually all quarantine pest risk assessments. Determination of entry rates can be achieved with relatively low degrees of uncertainty, and in some cases this may be enough to give us enough confidence in our risk management strategies to forgo anything more than a qualitative assessment of establishment potential. It is essential that national plant protection organisations collect, collate and disseminate information from intensive systematic inspections if we are to achieve quantitative analyses of pest risk that satisfy international trade requirements.

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## **APPENDIX I**

Inventory of insects collected in a survey of 3001 sea cargo containers stored in Brisbane container parks from February to September 1996\*

	No.	No.		No.	No.
Species	containers	insects	Species	containers	insects
BLATTODEA			(Ectobiidae cont.)		
Blattellidae			Unknown sp.	37 (11)	44 (12)
Blattella germanica (L.)	2	4	Total unknown family		56
Blattella sp.	1	2			
Robshelfordia sp.	1	3	Total Blattodea		260
Unknown sp.	15 (1)	19 (100)			
Total Blattellidae		128	COLEOPTERA		
Blattidae			Anobiidae		
Periplaneta americana (L.)	1	1	Anobium punctatum (De Geer)	1	1
Periplaneta australasiae (Fabricius)	2	2	Lasioderma serricorne (Fabricius)	22 (5)	130 (11)
Periplaneta sp.	18(7)	28 (9)	Lasioderma sp.	1	1
Polysosteria sp.	1	1	Ptinus fur (L.)	1	1
Unknown sp	18 (2)	28 (4)	Ptinus sp.	1	1
Unknown sp. <sup>†</sup>	1	1	Stegobium paniceum (L.)	3	3
Total Blattidae	-	74	Unknown sp.	7	11
Total Blatitude		, ,	Total Anobiidae		159
Ectobiidae					
Ectobius sp.	1	1	Anthicidae		
Unknown sp.	1	1	Anthicus sp.	2	2
Total Ectobiidae		2	Unknown sp.	7 (3)	41 (3)
Unknown family			Total Anthicidae		46

Species	No. containers	No. insects	Species	No. containers	No. insects
Bostrichidae			Cucujiidae		
Dinoderus minutus (Fabricius)	2	15	Cathartus sp.	1	2
Dinoderus sp.	1	1	Cryptolestes sp.	2	6
Heterobostrychus aequalis (Waterhouse)	10	17	Total Cucujiidae		8
Lyctus brunneus (Stephens)	6	7	Connectionsides		
Lyctus sp.	1	1	Euroallacaa sp	3	20
Mininea rugicouis (Walker) Rhyzopartha dominica (Febricius)	4	4 7 (2)	Hypothenemus sp	1	20
Rhyzopertha sp	6	9	Ins grandicollis (Eichhoff)	1	10
Sinoxylon anale Lesne <sup><math>\dagger</math></sup>	6	8	Mandalotus sp.	1	1
Unknown sp.	3	4	Sitona lineatus L.	1	1
<i>Xylopsocus</i> sp.	2	2	Sitophilus oryzae (L.)	5 (1)	5(1)
Xylothrips religiosus (Boisduval)	1	3	Sitophilus sp.	14 (5)	46 (18)
Xylothrips sp.	1	1	Sphenophorus brunnipennis (Germar)	1	1
Total Bostrichidae		81	Unknown scolytine	14(1)	23 (1)
			Unknown sp.	18(1)	26(1)
Brentidae	1	1	Unknown sp. '	1	l
Baryrnynchus sp.	1	1	<i>Xyleborus</i> sp.	4	16
Total Brentidae		1	Total Curculionidae		172
Cantharidae			Dermestidae		
Unknown sp.	1	1	Anthrenocerus sp.	1	1
Total Cantharidae		1	Anthrenus sp.	2 (2)	2 (2)
Carabidae			Attagenus sp.	4	12
Unknown sp	25	39	Dermestes ater De Geer	1	1
Tatal Cambidaa	20	20	Dermestes maculatus De Geer	11 (3)	46 (253)
Total Carabidae		59	Dermestes sp.	2	21
Cerambycidae			Trogoderma megatomoides Reitter	1	4
Arhopalus sp. <sup>†</sup>	4	7	Unknown en	1	1
Aromia moschata (L.)'	1	2	Unknown sp.	8(3)	23 (3)
<i>Clytus</i> sp.	1	1	Total Dermestidae		371
Phoracantha semipunctata (Fabricius)	2	2	Dytiscidae		
<i>F noracanina</i> sp. <i>Tetropium castaneum</i> $(\mathbf{L})^{\dagger}$	1	1	Rhantus suturalis Macleay	1	1
Unknown sp	13	16	Unknown sp.	1	1
Tatal Carambusidas	15	20	Total Dytiscidae		2
Total Cerambycidae		30	Elataridaa		
Chrysomelidae				1	1
Cryptocephalus iridipennis Chapuis	1	1	Agryphus sp. Conoderus sp	1	1
Lema trivittata Say	1	2	Unknown sp	9	14
Unknown galerucerine	37	4	Tatal Elataridas		16
Unknown sp	8	10	Iotal Elatendae		10
The life life life life life life life lif	0	10	Laemophloeidae		
Iotal Chrysomelidae		28	Cryptolestes sp.	2	3
Cleridae			Laemophloeus sp.	2	2
Necrobia ruficollis (Fabricius)	1	1	Unknown sp.	4	7
Necrobia rufipes (De Geer)	21 (2)	60 (52)	Total Laemophloeidae		12
Unknown sp.	5	1	Lathridiidae		
Total Cleridae		120	Aridius nodifer (Westwood) <sup>†</sup>	4(1)	8(1)
Coccinellidae			Corticaria sp.	3	3
Adalia bipunctata (L.) <sup>†</sup>	4	4	Lathridius minutus (L.)	5	12
Coccinella septempunctata $L$ . <sup>†</sup>	1	2	Thes bergrothi (Reitter) <sup>†</sup>	1	1
Coccinella transversalis Fabricius	5	5	Unknown sp.	1	1
Coelophora inaequalis (Fabricius)	1(1)	1(1)	Total Lathridiidae		26
Unknown sp.	10(2)	11 (6)	Mordellidae		
Unknown sp.'	1	1	Unknown sp	1	1
Total Coccinellidae		31	Unknown sp.	1	1
Cryptophagidae			Total Mordellidae		1
Cryptophagus varus Woodroffe & Coom	bs† 1	1	Mycetophagidae		
Unknown sp.	1	2	Typhaea stercorea (L.)	5 (1)	11 (2)
Total Cryptophagidae		3	Total Mycetophagidae		13

Species	No. containers	No. insects	Species	No. containers	No. insects
Nitidulidae			COLLEMBOLA		
Brachypeplus sp.	0(1)	0(2)	Unknown family		
<i>Carpophilus hemipterus</i> (L.)	5(1)	18 (1)	Unknown sp.	1	4
Carpophilus obsoletus Erichson <sup>†</sup>	1	1	Total unknown family		4
Carpophilus sp.	4	6			-
Unknown sp.	13 (1)	21 (10)	Total Collembola		4
Total Nitidulidae		59			
Distance di da a			DERMAPTERA Existence		
Platypouldae	2	2	Forneundae Unknown an	2	5
Lukpown sp	2	3	Clikilowii sp.	5	5
The LDL of LL	2	0	Total Forficulidae		5
Total Platypodidae		11	Unknown family		
Scarabaeidae			Unknown sp.	39	67
Adoretus sinicus Burmeister <sup>†</sup>	1	2	Total unknown family		67
Adoretus sp. <sup>†</sup>	1	1	T-t-1 D-montem		72
Dasygnathus sp.	1	1	Total Dermaptera		12
Harmogaster sp.	1	1			
Heteronychus arator (Fabricius)	1	3	Anthomyiidae		
Heteronyx sp.	1	1	Unknown sp	3	3
Onthophagus sp.	1	1	Enknown sp.	5	5
Phyllotocus macleayi Fischer	1	1	Total Anthomyndae		3
Sericesthis sp.	l	1	Asilidae		
Unknown sp.	16	22	Unknown sp.	1	3
Total Scarabaeidae		34	Total Asilidae		3
Silvanidae			Callinharidaa		
Ahasverus advena (Waltl)	15 (4)	22 (6)		7	0
Oryzaephilus mercator (Fauvel)	10 (5)	36 (10)	Luciuu sp. Unknown sp	11	55
Oryzaephilus surinamensis (L.)	4 (7)	6 (22)		11	55
Oryzaephilus sp.	1	1	Total Calliphoridae		64
Silvanus platanus Germar <sup>†</sup>	3	6	Cecidomyiidae		
Silvanus unidentatus Olivier	6	11	Unknown sp.	2	3
Silvanus sp.	1	1	Total Cecidomyiidae		3
Unknown sp.	4(1)	12 (1)			
Total Silvanidae		134	Ceratopogonidae	2	2
Staphylinidae			Unknown sp.	2	2
Unknown sp	23 (6)	31 (6)	Total Ceratopogonidae		2
Total Stanbulinidaa	20 (0)	27	Chironomidae		
Total Staphynnidae		57	Unknown sp.	21(1)	31(1)
Tenebrionidae			Total Chironomidae		37
Alphitobius diaperinus (Panzer)	10	19	Total Chirononidae		52
Alphitobius laevigatus (Fabricius)	9(1)	14 (1)	Culicidae		
Alphitobius sp.	1	1	Aedes vigilax (Skuse)	2(1)	2 (1)
Gonocephalum sp.	3	6	Aedes sp.	1	1
Mesomorphus sp.	3	4	Culex annulirostris Skuse	3	3
Tribolium castaneum (Herbst)	228 (41)	734 (112)	Culex australicus Dobrotworsky	1	1
Inbolium sp.	15(11)	52 (48)	& Drummond	_	0
Unknown sp.	28	32	Culex quinquefasciatus Say	7	9
Unknown sp.	Z	2	Culex sp.	1	65
Total Tenebrionidae		1325	Unknown sp.	30	46
Tenebrionoidea			Total Culicidae		128
Unknown sp.	0(1)	0 (6)	Dolichopodidae		
Total Tenebrionoidea		6	Unknown sp.	3	3
		Ū.	Total Doliahanadidaa		2
	2	2	iotai Donenopouluae		3
Lophocateres pusillus (Klug)	2	2	Drosophilidae		
Total Trogositidae		2	Unknown sp.	3	26
Unknown family			Total Drosophilidae		26
Unknown sp.	220 (19)	626 (36)	*		
Total unknown family	- \ - /	662	Empididae	1	1
iotai unknown idilliy		002	Unknown sp.	1	1
Total Coleoptera		3430	Total Empididae		1

PRA of insects in containers 189

MercepeideUnknown sp.12Unknown sp. 2011)261(1)565Total Micropezide2Total unknown fumily565MuscidaTotal unknown fumily565Muscida82Elemental sp.2Total MicropezideTotal Unknown sp.22Mottorian3Total Objeomida22Mottorian3Total Objeomida22Total Micropezide3Unknown sp.22Total Micropezide3Unknown sp.11Unknown sp.11Total unknown fumily1Total Nicola Nerrida1111Total Nicola Nerrida1111Total Nerrida64Unknown fumily11Probation11111Total Nerrida406Unknown fumily11Proponitalia64Total Centralia21Proponitalia11111Proponitalia11111Proponitalia Cole (Walker)1211Proponitalia Cole (Walker)1211Proponitalia Cole (Walker)1211Proponitalia Cole (Walker)1111Unknown sp.11111Proponitalia Cole (Walker)72111Unknown sp.1 <th>Species</th> <th>No. containers</th> <th>No. insects</th> <th>Species</th> <th>No. containers</th> <th>No. insects</th>	Species	No. containers	No. insects	Species	No. containers	No. insects
Total Micropezidae2Total Diptra555MacidaeTotal Diptra2/48Macidae82Diptomida2Total Misciolae82Diptomida2Total Misciolae82Olipsomidae2Uaknown sp.33Total Afgeotomidae2Uaknown sp.33Total Misciolae1Newteenphildae3Uaknown family1Uaknown sp.11Total Miscione family1Total Nycetophildae1Total Miscione family1Provinkae11Total Miscione family1Total Neridae1Total Miscione sp.11Total Neridae674Caeridae31Provinkae12Total Lienelae11Provinka406Uaknown sp.111Provinka2Total Uknown sp.111Provinka12Total Uknown sp.266Total Aberloade2Total Aberloade261Provinka12Total Lienew sp.111Provinka12Total Uknown sp.266Total Science2Total Discourde2611Provinka11111111Provinka11111111Provinka1 </td <td>Micropezidae Unknown sp.</td> <td>1</td> <td>2</td> <td>Unknown family Unknown sp.</td> <td>261 (1)</td> <td>564 (1)</td>	Micropezidae Unknown sp.	1	2	Unknown family Unknown sp.	261 (1)	564 (1)
MaceidaeTotal DiperaZel8Unknown sp.4282EMICOTERAIMycetophilidaeIIkanown sp.22Unknown sp.33Total Oligotomidae22Total MycetophilidaeIIkanown sp.111NerikaeIIkanown family111NerikaeIITotal Inknown family11Total NoretophilidaeIII11NorikaeIIIIIITotal NoretophilidaeIIIIIProvidaeIIIIIITotal ProvidaeIIIIIIProvidaeIIIIIIITotal ProvidaeIIIIIIIProvidaeIIIIIIITotal ProvidaeIIIIIIIProvidaeIIIIIIIIIProvidaeIII <td>Total Micropezidae</td> <td></td> <td>2</td> <td>Total unknown family</td> <td></td> <td>565</td>	Total Micropezidae		2	Total unknown family		565
Unknown sp.4282FMBIOPTERA OligiournidaeNetwork sp.22Total Musculae1Valcuown sp.22Unknown sp.33Tutal Oligiotomidae2Neridae1Unknown family11Unknown sp.11Total Mycorbyhildae1Neridae1Total Embioptera33Phoridae62PHIEMEROPTERA Caenidae11Unknown sp.1111Phoridae674Unknown sp.11Phoridae674Unknown family1Total Phoribidae674Unknown sp.11Phoridae674Unknown family11Phoridae674Unknown family11Phoridae674Unknown family11Total Phoridae674Unknown sp.11Phoridae674Unknown sp.11Phoridae7Total Unknown family11Total Phoridae86Total Anthocoridae2320Total Phoridae86Total Anthocoridae2323Sarcophagidae7111Unknown sp.7111Total Sciaridae72Philidae21Unknown sp.71111Total Sciaridae7111Unknown sp.711 </td <td>Muscidae</td> <td></td> <td></td> <td>Total Diptera</td> <td></td> <td>2248</td>	Muscidae			Total Diptera		2248
Total Muscidae         82         Oilgaomidae           Mycetophildae         1         Unknown p.         2           Total Mycetophildae         3         Unknown family         2           Total Mycetophildae         3         Unknown family         1         1           Neritokae         1         1         Total known family         1         1           Neritokae         1         1         Total known family         1         1           Neritokae         1         1         Total known family         1         1           Total Phoridae         674         Unknown sp.         1         1         1           Total Dinknown sp.         1         1         1         1         1           Unknown sp.         12         406         Unknown sp.         1         1           Physponatidae         Total Dinknown family         1         1         1           Physponatidae         Total Unknown sp.         1         1         1           Physponatidae         1         2         Total Dinknown sp.         2         2         3           Total Dinknown sp.         12         1         1         1         1         <	Unknown sp.	42	82			
MycerophildaeUnknown sp.22Unknown sp.33Toral Ofigotonidae2NerikaeJuknown sp.11Nerikae1Total Unknown family1Nerikae1Total unknown family3Phoridae1Total Unknown sp.3Phoridae1Total Unknown sp.1Total Phoridae674Unknown sp.1Phoridae674Unknown sp.1Phoridae674Unknown sp.1Total Phoridae406Unknown sp.1Total Phophildae406Unknown sp.1Total Phophildae11Phoridae211Phoridae211Phophildae121Total Phophildae211Phophildae211Phoridae211Total Phophildae211Phoridae211Phoridae211Phoridae211Unknown sp.1211Phoridae2111Unknown sp.1211Phoridae2111Unknown sp.7211Unknown sp.7211Total Sciardae7211Unknown sp.711	Total Muscidae		82	EMBIOPTERA Oligotomidae		
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PhoridaePHEMEROPTERA CanvidaePHEMEROPTERA CanvidaeIITotal Pioridae674Unknown sp.11Piophilidae704PioneTotal Canvidae11Piophilidae12406Unknown family11Playstomatidae406Unknown sp.111Playstomatidae12Total Liphemeroptera22Total Piophilidae12Total Ephemeroptera22Total Piophilidae12Total Anthocoridae26 (17)Psycholidae85 (1)Unknown sp.2 (2)6 (17)Total Psycholidae729Unknown sp.2 (2)6 (17)Total Psycholidae729Unknown sp.11Total Sarcophagidae729Unknown sp.11Ciaridae712Philaeme symmetrik L <sup>1</sup> 11Total Scrindae712Philaeme symmetrik L <sup>1</sup> 11Total Scrindae6Andridae111Total Sepsidae2 (1)6 (1 1)Andridae111Total Sepsidae319Aradidae1111Total Sepsidae310Cacellidae1111Total Sepsidae310111111111111111111 </td <td>Total Neriidae</td> <td></td> <td>1</td> <td>Total Embioptera</td> <td></td> <td>3</td>	Total Neriidae		1	Total Embioptera		3
Unknown sp.         41 (s)         269 (40S)         EPHEMEROPTERA Careiralea           Total Phoridae         674         Unknown sp.         1         1           Piophilidae         Total Caenidae         1         1           Unknown sp.         12         406         Unknown sp.         1         1           Total Piophilidae         406         Unknown sp.         1         1           Paystomatidae         Total Unknown sp.         1         2         1         2           Total Playstomatidae         2         Total Unknown sp.         2 (2)         6 (17)           Progenoratida dorlea (Walker)         1         2 (1)         8 (1)         Unknown sp.         2 (2)         6 (17)           Total Physychodidae         B6         Total Anthocoridae         23         Sarcophagidae         2 (2)         6 (17)           Total Scrophagidae         2 (2)         Total Anthocoridae         2 (2)         6 (17)           Total Scrophagidae         2 (2)         Total Anthocoridae         2 (2)         6 (17)           Total Scrophagidae         2 (2)         Total Anthocoridae         2 (2)         6 (17)           Total Scrophagidae         12 (2)         Philagara parara (Donowan)         1 (1	Phoridae			L L		
Total Phoridae         674         Unknown sp. Total Caenidae         1         1           Piophilidae         Total Caenidae         1         1           Total Piophilidae         406         Unknown family         1           Total Piophilidae         406         Unknown family         1           Playstomatidae         1         2         1           Playstomatidae         1         2         1           Progenoratifis doclea (Walker)         1         2         1           Total Piophilidae         2         1         2           Psychodidae         86         Total Anthocoridae         2           Unknown sp.         1         1         1         1           Total Surcophagidae         29         Total Aphitocoridae         1         1           Unknown sp.         7         12         Philaerus symarius L <sup>+</sup> 1         1           Total Surcophagidae         12         Philaerus symarius L <sup>+</sup> 1         1         1           Unknown sp.         7         12         Philaerus symarius L <sup>+</sup> 1         1           Total Surcophagidae         12         Philaerus symarius L <sup>+</sup> 1         1	Unknown sp.	41 (5)	269 (405)	EPHEMEROPTERA		
Piophilidae       Total Caenidae       I         Unknown sp.       12       406       Unknown family       I         Total Piophilidae       406       Unknown sp.       1       1         Playstonatidae       Total Unknown sp.       1       1       1         Pogonortalis doclea (Walker)       1       2       Total Pinemeroptera       2         Total Playstonatidae       2       EMIPTERA       2       6(17)         Sychodidae       85       Total Anthocoridae       23         Sarcophagidae       Anthocoridae       23       6(17)         Total Psychodidae       86       Total Anthocoridae       1       1         Unknown sp.       7       9       Unknown sp.       1       1         Total Sarcophagidae       29       Total Aphididae       1       1         Unknown sp.       7       12       Philaemens symaarins L <sup>+</sup> 1       1         Total Sciaridae       12       Philaemens symaarins L <sup>+</sup> 1       1       1         Unknown sp.       7       12       Philaemens symaarins L <sup>+</sup> 1       1       1         Total Sciaridae       12       Philaemens symaarins L <sup>+</sup> 1       1	Total Phoridae		674	Unknown sp	1	1
Interven         12         406         Intervention         Intervention           Total Prophilidae         406         Unknown sp.         1         1           Paty stomatidae         7         101         1         1           Paty stomatidae         2         Total Unknown family         1         2           Pogenoratida docka (Walker)         1         2         Total Depenceroptera         2           Pogenoratida docka (Walker)         1         2         Total Depenceroptera         2           Pogenoratida docka (Walker)         12         1         Anthecoridae         23           Sarcophagidae         Total Anthocoridae         23         5         5           Sarcophagidae         29         Total Anthocoridae         23         5           Sarcophagidae         29         Total Aphrophoridae         1         1           Unknown sp.         7         29         Unknown sp.         1         1           Total Sarcophagidae         12         Philagra parva (Donovan)         1         1           Unknown sp.         7         12         Philagra parva (Donovan)         1         1           Total Saratidnee         6         Total Aphrophoridae <td>Piophilidae</td> <td></td> <td></td> <td>Total Caenidae</td> <td>1</td> <td>1</td>	Piophilidae			Total Caenidae	1	1
Total Piophilidae       406       Unknown sp.       1       1         Play stomatidae       Total Unknown family       1       2         Pogenoratifs doclea (Walker)       1       2       Total Piphemeroptera       2         Total Play stomatidae       2       HEMIPTERA       2         Psychodidae       86       Total Anthocoridae       23         Vaknown sp.       12 (1)       85 (1)       Unknown sp.       2 (2)       6 (17)         Total Psychodidae       86       Total Anthocoridae       23         Sarcophagidae       Aphididae       1       1         Unknown sp.       7       29       Total Aphididae       1       1         Unknown sp.       7       12       Philagra para (Donovan)       1       1       1         Sciaridae       12       Philagra para (Donovan)       1       1       1       1         Total Sciaridae       62       Total Aphrophoridae       1       1       1       1         Sepsidae       62       Total Aradidae       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1	Unknown sp.	12	406	Unknown family		1
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IndependenceImage: Constraint of the section of the sec	Platystomatidae			Total Unknown family		1
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HEMIPTERA         Mnthocoridae       Anthocoridae         Unknown sp.       12 (1)       85 (1)       Unknown sp.       2 (2)       6 (17)         Total Psychodidae       86       Total Anthocoridae       23         Sarcophagidae       Aphididae       1       1         Unknown sp.       7       29       Total Anthocoridae       1       1         Total Sarcophagidae       29       Total Aphididae       1       1       1         Sciaridae       29       Total Aphididae       1	Total Platystomatidae		2	ioui Epieneropiera		2
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Total Psychodidae       86       Total Anthocoridae       2 (z)       6 (17)         Sarcophagidae       Aphididae       23         Unknown sp.       7       29       Unknown sp.       1       1         Total Sarcophagidae       29       Total Aphididae       1       1         Sciaridae       29       Total Aphididae       1       1       1         Sciaridae       20       Philagra parva (Donovan)       1       1       1         Total Sepsidae       7       12       Philagra parva (Donovan)       1       1       1         Sciaridae       12       Philagra parva (Donovan)       1	Unknown sp.	12(1)	85(1)	Anthocoridae	2 (2)	6 (17)
Total AtlintCorriade       25         Unknown sp.       7       29       Unknown sp.       1       1         Total Sarcophagidae       29       Total Aphididae       1       1         Sciaridae       29       Total Aphididae       1       1         Sciaridae       29       Total Aphrophoridae       1       1         Sciaridae       12       Philagra parva (Donovan)       1       1         Total Sciaridae       12       Philagra parva (Donovan)       1       1         Sepsidae       12       Unknown sp.       1       1       1         Strationyidae       62       Unknown sp.       1       1       1         Strationyidae       62       Unknown sp.       1       1       1         Hermetia illucens (L.)       3       6       Arawa sp. <sup>†</sup> 1       1       1         Unknown sp.       5       9       Exitanus indicas (Distant) <sup>†</sup> 1       1       1         Unknown sp.       3       3       Total Cicadellidae       6       6       1       1         Strationyidae       3       Qydnidae       1       1       1       1       1         <	Total Psychodidae		86	Total Anthonoridae	2(2)	0(17)
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Total Tipulidae15Total Flatidae1	Unknown sp.	15	15	riatidae Unknown sp <sup>†</sup>	1	1
	Total Tipulidae		15	Total Flatidae	-	1

Species	No. containers	No. insects	Species	No. containers	No. insects
Largidae			Diapriidae		
Physopelta sp.	1	1	Unknown sp.	1	1
Total Largidae		1	Total Diapriidae		1
Lygaeidae			Evaniidae		
Geocoris sp.	3	3	Unknown sp.	1	1
Nysius vinitor Bergroth	1	2	Total Evaniidae		1
Unknown sp.	16 (2)	26 (2)	Formicidae		
Total Lygaeidae		33	Anoplolepis sp. <sup>†</sup>	1	2
Meenoplidae			Camponotus sp.	1	6
<i>Nisia</i> sp.	1	1	Cardiocondyla sp. $^{\dagger}$	1	1
Total Meenoplidae		1	Crematogaster sp.	3	11
Miridae			<i>Ectatomma</i> sp. 1	1	1
Unknown sp.	2	3	Odontomachus sp <sup>†</sup>	9(3)	30(7)
Total Miridae		3	Paratrechina sp.	2	2
Nabidae			Pheidole sp.	11 (4)	28 (44)
Unknown sp.	1	2	Polyrhachis sp.	4 (1)	14 (1)
Total Nabidae		2	Solenopsis sp. <sup>†</sup>	1	1
Pentatomidae			Technomyrmex sp.	1	1
Eumecopus sp.	1	1	<i>Tetramorium</i> sp. Unknown poperine	1	1
Nezara viridula (L.)	1	1	Unknown sp.	84 (9)	169 (65)
Unknown sp.	5	5	Total Formicidae		389
Total Pentatomidae		7	Total Formedae		507
Reduviidae			Ichneumonidae	1	2
Unknown sp.	1	1	Lissonoia sp. Netelia sp	1	5
Total Reduviidae		1	Rhyssa persuasoria (L.) <sup>†</sup>	1	1
Phopalidae			Rhyssa sp.	4	5
Unknown sp	1	1	Unknown sp.	1	1
Total Phonalidae	1	1	Total Ichneumonidae		11
		1	Megachilidae		
Unknown family	64 (2)	00(2)	Unknown sp. <sup>†</sup>	1	1
Unknown sp.	04 (2)	99 (3)	Total Megachilidae		1
Total unknown family		102			-
Total Hemiptera		195	Pteromalidae	1	1
			Tatal Drammalida	1	1
Apidae			Total Pteromandae		1
Apis mellifera L.	1	1	Siricidae		
Total Apidae		1	Sirex juvencus $(L.)^{\dagger}$	2	3
A == i d==		-	Urocerus sp †	1	1
Apoldea Unknown sp	3	3	Total Sinisidas	2	2 6
Total Apoidea	5	3	Total Shicidae		0
		3	Sphecidae	2	2
Braconidae	17	27	Sceliphron sp.	2	3
Unknown sp.	17	27	Unknown sp.	2	2
Total Braconidae		27	Total Sphecidae		5
Chalcididae			Tiphiidae		
Unknown sp.	1	1	Anthobosca sp.	1	1
Total Chalcididae		1	Total Tiphiidae		1
Chrysididae			Unknown family		
Chrysis ignita L. <sup>†</sup>	1	1	Unknown sp.	23	44
Unknown sp.	1	1	Total unknown family		44
Total Chrysididae		2	Vesnidae		
Colletidae			Delta campaniforme (Fabricius)	1	1
Unknown sp.	1	1	Polistes gallicus $(L.)^{\dagger}$	3	3
Total Colletidae		1	Ropalidia socialistica (Saussure)	1	1

Species	No. containers	No. insects	Species	No. containers	No. insects
(Vespidae cont.)			Pyralidae		
Vespula austriaca (Panzer) <sup>†</sup>	1	1	Cnaphalocrocis medinalis (Guenée)	1	1
Vespula germanica (Fabricius)	2	2	Ephestia cautella (Walker)	5	18
Vespula rufa (L.) <sup>†</sup>	1	1	<i>Ephestia</i> sp.	0(1)	0(1)
Vespula vulgaris (L.) <sup>†</sup>	3	13	Herpetogramma licarsisalis (Walker)	12	28
Vespula sp.	1	1	Maruca testulalis (Geyer)	1	1
<i>Vespula</i> sp. <sup>†</sup>	2	2	Plodia interpunctella (Hübner)	1	1
Total Vespidae		25	Unknown sp.	3(1)	7(1)
Total Hymenoptera		520	Total Pyralidae		58
ISOPTERA			Sphingidae	1	1
Kalotermitidae			Deneprina sp.	1	1
Unknown sp.†	1	4	Total Sphingidae		1
Total Kalotermitidae		4	Tortricidae	2(1)	16 (2)
Rhinotermitidae			Ulikilowil sp.	5(1)	10(2)
Coptotermes sp.	1	20	Total Tortricidae		18
Unknown sp.	15	45	Unknown family		
Total Rhinotermitidae		65	Unknown sp.	146 (9)	276 (9)
Unknown family			Total unknown family		285
Unknown sp.	11	18	Total Lepidoptera		433
Total unknown family		18			
Total Isoptera		87	NEUROPTERA		
1			Chrysopidae	10	12
LEPIDOPTERA			Unknown sp.	10	13
Arctiidae			Total Chrysopidae		13
Utetheisa pulchelloides Hampson	1	1	Unknown family		
Total Arctiidae		1	Unknown sp.	2	2
Carposinidae			Total unknown family		2
Unknown sp.	0(1)	0(3)			15
Total Carnosinidae		3	Total Neuroptera		15
L'impositione		5	ODONATA		
Limacodidae	1	1	Coenagrionidae		
Ulkilowii sp.	1	1	Unknown sp.	1	1
Total Limacodidae		1	Total Coenagrionidae		1
Lycaenidae			The LOL		
Jamides sp. <sup>†</sup>	1	1	Total Odonata		1
Total Lycaenidae		1	ΟΡΤΗΟΡΤΕΡ Δ		
Lymantriidae			Acrididae		
Unknown sp.	1	1	Aiolopus thalassinus Fabricius	1(1)	1(1)
Total Lymantriidae		1	Unknown sp.	1	2
Noctuidae			Total Acrididae		4
Agrotis munda Walker	1	1			
Helicoverpa armigera (Hübner)	2	2	Ensilera	1	1
Heliothis rubrescens (Walker)	1	1	Ulikilowil sp.	1	1
Mocis trifasciata (Stephens)	1	1	Total Ensifera		1
Mythimna convecta (Walker)	5	8	Gryllidae		
Mythimna sp.	2	2	Acheta commodus Walker	2	3
Pataeta carbo (Guenée)	1	1	Gryllodes sigillatus (Walker)	9 (2)	10(2)
Persectania ewingii (Westwood)	2	3	Gryllodes sp.	8 (1)	10(1)
Plusia festucae (L.)	1	1	Lepidogryllus parvulus (Walker)	1	1
Spodoptera litura (Fabricius)	4	4	Metioche sp.	2(1)	7(1)
Spodoptera mauritia (Boisduval)	16	26	Teleogryllus sp.	3	3
Spoaoptera sp.	2	2	Unknown sp.	23 (4)	(/) 00
Total Noctuidae	/(1)	63	Total Gryllidae		81
Total moctuluae		05	Tettigoniidae		
Nymphalia with wet (C = 1 = 1) <sup>†</sup>	1	1	<i>Pseudorhynchus</i> sp.	1	1
Tymphulis muberil (Godart)	1	1	Unknown sp.	1	1
Iotal Nymphalidae		1	Total Tettigoniidae		2

# **APPENDIX I** continued

Species	No. containers	No. insects	Species	No. containers	No. insects
Unknown family			(SIPHONAPTERA cont.)		
Unknown sp.	11 (1)	12(1)	Total unknown family		1
Total unknown family		13	Total Siphonaptera		1
Total Orthoptera		101	THYSANOPTERA		
			Phlaeothripidae		
PSOCOPTERA			Unknown sp.	1	1
Liposcelidae			Total Phlaeothripidae		1
Liposcelis sp.	4(1)	11 (4)			-
Unknown sp.	0(1)	0(1)	Unknown family		
Total Liposcelidae		16	Unknown sp.	1	1
Tradidae			Total unknown family		1
Unknown sp	1 (1)	1 (1)	Total Thysanoptera		2
	1 (1)	1(1)	<b>v</b> 1		
Total Troglidae		2	THYSANURA		
Unknown family			Lepismatidae		
Unknown sp.	8 (4)	12 (5)	Ctenolepisma sp.	3	3
Total unknown family		17	Unknown sp.	1	1
		17	Total Lepismatidae		4
Total Psocoptera		35	Links over formily		
			Unknown family	9 (1)	0 (4)
SIPHONAPTERA			Unknown sp. Total Unknown	0 (4)	9 (4)
Unknown family					15
Unknown sp.	1	1	Total Thysanura		17

<sup>†</sup>Exotic.

\*Numbers in parentheses indicate live specimens found in addition to dead specimens.