EXOTIC ARTHROPOD PESTS OF CONCERN TO THE AUSTRALIAN CITRUS INDUSTRY

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1. SUMMARY

This paper provides an overview of the exotic arthropod pests of concern to the Australian citrus industry. The paper briefly describes the analytical process used to categorise these pests and lists approximately 70 high and moderate risk pests.

2. THE ANALYTICAL PROCESS

The list of high and moderate risk exotic pests presented here (Attachment 1) has been derived by evaluation of species that have been associated with citrus throughout the world.

An extensive inventory of potential exotic citrus pests was compiled by drawing upon published lists and pest information (principally Smith et al. 1997; but also Davies & Albrigos 1994, and Smith & Penna 2002), unpublished Biosecurity Australia Pest Risk Analyses, unpublished reports to the Northern Australia Quarantine Strategy (NAQS) and a selective review of primary literature.

For arthropods it is appropriate to consider four factors as contributing to exotic pest significance, and, in the context of this project, to relevance for the biosecurity of the Australian citrus industry. The four factors, entry, establishment, spread potential and likely impact, are described below. Species were ranked accordingly (Attachment 1). The draft list was then circulated to Australian entomologists familiar with the identification or management of arthropod citrus pests for further suggestions, comments and endorsement.

The development of target lists is to some extent subjective, and it is freely acknowledged that others may rank the threats differently.

2.1 Entry potential

The risk analysis recognised species as having significant entry potential which:

I) are present in countries from which Australia currently imports citrus material or present in countries from which illegally imported citrus material has been most commonly sourced, and:
   i) are present on imported material, and are
   ii) likely to escape quarantine detection.

II) a credible means of natural introduction (e.g. windblown) could be recognised, and:
   i) currently occur in close geographic proximity to Australia, and are
   ii) capable of long-range dispersal.

Species likely to be introduced through importation (legal or otherwise) were considered. Small and /or cryptic pests, such as exotic mites and scale insects, generally emerged from the analysis as high risk species.

For legally imported fruit, current methods of production and commodity protection in the place of origin, and standard treatment and inspection procedures were considered in the analysis. For contraband material, current procedures used to detect plant material at the barrier were assumed. Interception records (e.g. as recorded in the AQIS PDI Database) provided some additional indication as to whether a particular species was likely to be found on citrus material in transit internationally.

Species for which natural introduction seemed feasible, were rated according to their geographic proximity and mode of dispersal. Thus, wind-dispersed species occurring to Australia's near north (e.g. whiteflies in Indonesia and Papua New Guinea) were rated as higher risks than sedentary species occurring in the same geographical area. For minute species such as thrips, wind dispersal over vast ocean distances is feasible under prevailing wind directions.

2.2 Establishment potential

The risk analysis identified species as likely to establish founder populations if:

III) capable of rapid rates of population increase;
IV) polyphagous (diverse host range); and
V) existing in a similar climate to parts of Australia with potential host plants.

For example, parthenogenic and/ or polyphagous species such as aphids and scale insects generally emerged from the analysis as species with a high probability of establishment and therefore high risk species.

Similarities between the climate of the source and receiving regions also enhance the chances of survival of adventive species. However, in the present analysis, no species were eliminated from further consideration for want of a climatic match with some part of Australia.

Species with a documented history of establishment in new areas were rated as high risks of establishment in Australia. Several exotic fruit fly species have such histories.

2.3 Spread potential

Species which were likely to spread from founder populations were deemed to be those which:

VI) are strong fliers;
VII) have a tendency to be passively dispersed on wind currents; and
VIII) have a propensity towards human facilitated spread.

Some of the factors relevant to establishment also influence the rate of spread of an arthropod pest. For example, species climatically suited to Australian conditions, able to feed or develop on a wide range of common host plants, or with high reproductive rates; are also likely to be good dispersers. For several species it was noted that alternative hosts plants, such as the ornamental *Murraya,* could facilitate the spread of arthropod pests of citrus throughout Australia.

2.4 Impact

Estimating the likely impact of exotic pests on citrus production and profitability has proved a significant challenge. Relying upon published assessments and the expert opinion of Australian specialists, the present study acknowledged those species that

were described as 'serious pests' or 'of major economic importance' by rating them as high risk species.

Pest status was downgraded if one or more natural enemies of an exotic pest already existed in Australia, on the grounds that the impact of the pest most likely would be mitigated almost immediately. In other cases it was felt that current management practices would be effective against a particular new pest, at a minimal cost increment.

3. INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) has emerged as the viable strategy for dealing with the multitudinous pests of citrus. This approach has been developed as an alternative to reliance on chemical interventions. As a result of strategic, reduced and highly selective applications of pesticides, natural enemies are conserved, the onset of pesticide resistance can be delayed, pesticide residues on fruit and in the environment are minimised and grower costs are reduced.

The cornerstones of IPM are a sound knowledge of pest biology, effective biological control, and the selective use of pesticides. It could be argued that the most appropriate assessment of the potential impact of an exotic citrus pest would be one that determined how effectively and how quickly the pest species might be encompassed by IPM strategies. The result of such an assessment would be that exotic species with 'difficult' characteristics (e.g. no known natural enemies) might be identified as greater risks than species apparently amenable to IPM. The assessment, in turn, could provide input to the more broadly based, cost-benefit analyses that increasingly guide those who must chose the appropriate response to a pest risk.

4. A TARGET LIST OF EXOTIC PESTS OF CITRUS

Via this analytical process, a target list of high and moderate priority exotic pest of citrus has been developed (Attachment 1). Additional information on each species is found in the comments column.

REFERENCES:

1. Davies, F.S. and Albrigos, L.G. 1994. Crop Production Science In Horticulture 2: Citrus. CAB International, Wallingford.
2. Smith, D., Beattie, G.A.C. & Broadley, R. 1997. Citrus pests and their natural enemies: integrated pest management in Australia. Queensland Dept. of Primary Industries.
3. Smith, D & Pena, J.E. 2002. Tropical Citrus Pests. *In* Pena, J.E., Sharp, J.L. **Tropical Fruit Pests & Pollinators – their Biology, Economic Importance, Natural Enemies and Control.** CABI Publishing, Wallingford.

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ATTACHMENT 1: Arthropod Pest Risk Analysis of key Citrus Pests - notes on risk potential

Priority Ranking	Pest	Classification	Distribution	Comments
High	*Aculops pelekassi* (pink citrus rust mite)	Acarina: Eriophyidae	Thailand; China; Italy; Japan; USA	Small and likely to escape detection on imported plant material. High reproductive rate but narrow host range. Easily spread by wind. Moderate economic impact, affecting fruit quality and quantity.
	Calacarus citrifolii (citrus grey mite, citrus blotch mite)		South Africa	Small and likely to escape detection on imported plant material. High reproductive rate and numerous alternate hosts. High spread potential, on wind; facilitated by wide host range. High economic impact through feeding damage and also believed to incite concentric ring blotch disease, which is associated with a spiroplasma-like organism.
	Eutetranychus africanus (citrus brown mite)	Acarina: Tetranychidae	Thailand; South Africa	High entry potential; occurs on fruit, small and likely to escape detection. Spread by wind, facilitated by wide host range. Moderate economic impact on citrus. May cause damage to leaves and premature fruit drop.
	Brevipalpus californicus (bunch mite)	Acarina: Tenuipalpidae	USA; Australia; Asia; South America; Africa; Europe	*B. californicus, B. obovatus* and *B. phoenicis* already occur in Australia, with moderate economic impacts. However, these mites are "inactive" vectors of the presently exotic and high economic impact citrus disease, *citrus leprosis rhabdovirus* (CiLV). Therefore, these mites should still be treated as quarantinable pests on the basis of their vectoring ability. The mites are minute, slow moving and occur on fruit, therefore entry potential risk is high.
	Brevipalpus obovatus (privet mite)		USA; Australia; Europe; Asia; Middle East	
	Brevipalpus phoenicis (passionvine mite)		USA; Australia; Indonesia; South Africa; Asia	
	Scirtothrips aurantii (South African citrus thrips)	Thysanoptera: Thripidae	USA; Africa	Some accounts indicate that it occurs predominantly on young fruit. Numerous alternate hosts. Although wind-borne, recorded as slow moving. High economic impact; largely cosmetic damage but rendering fruit unsuitable for market (especially export).
	Scirtothrips citri		USA	Occurs predominantly on young fruit. Numerous alternate hosts. Although wind-borne, recorded as slow moving. High economic impact, largely cosmetic damage but rendering fruit unsuitable for market (especially export Serious pest of citrus only in California. Polyphagous.
	Homalodisca coagulata (glassy winged sharpshooter)	Hemiptera: Cicadellidae	USA (Florida)	Eggs unlikely to be on fruit; immature and adult leafhoppers possibly as contaminants in fruit, especially on leaf or stem material. Numerous alternate hosts; recent history of spread in USA, especially on nursery stock. High economic impact; vector of citrus variegated chlorosis (CVC). Flatid and ricaniid leafhoppers already in Australia on citrus are phloem feeding; the citrus jassid present in Australia is xylem feeding and possibly could also serve as vector of CVC if the pathogen were introduced.

Priority Ranking	Pest	Classification	Distribution	Comments
High	*Diaphorina citri* (Asian citrus psylla)	Hemiptera: Psyllidae	Thailand; Vietnam; China; Malaysia; Japan	Unlikely to be on fruit. High potential to establish and spread. Vector of the serious disease citrus greening (Huanglongbing). A contingency plan for eradication should be a high priority (Brown 1998[1]).
	Trioza erytreae (African citrus psylla)		?Iran; South Africa	Vector of African form of citrus greening. High establishment and dispersal capabilities.
	Aleurotuberculatus acubae (coral whitefly)	Hemiptera: Aleyrodidae	China; Korea; S.E. Asia	Unlikely to be on harvested or treated fruit. High establishment potential. High economic impact; important pest in south China. Moderate rate of spread, however capable of spreading to all citrus growing areas in Australia.
	Dialeurodes citri (citrus whitefly)		USA; Spain; Italy; Egypt; China; Japan; Korea; Thailand; Vietnam	Unlikely to be on harvested and treated fruit. High establishment and spread potential. High economic impact; one of the most important pests of citrus; heavy infestations may cause deterioration of trees and crop failure. Chemical resistance.
	Parabemisae myricae (Japanese bayberry whitefly)		China; Japan; Malaysia; USA; Israel.	Small and likely to be on harvested fruit. High establishment potential. Not a very effective flier. High economic impact on citrus and avocado. Heavy infestations cause tree defoliation. Suspected vector of Citrus Chlorotic Dwarf Virus.
	Paracoccus burnerae (oleander mealybug)	Hemiptera: Pseudococcidae	South Africa	High entry potential: adults and crawlers likely to be on harvested fruit. High establishment potential. Crawlers dispersed on wind or nursery material. High economic impact; said to be among the three most important pest species on citrus in South Africa; however, sometimes confused with another serious pest, *Planococcus citri*.
	Pseudococcus cryptus (citrus mealybug)		Israel; Mediterranean region; Japan; S.E. Asia.	Wide host range. Common and damaging pest of citrus in Israel; attacks all parts of plant, including roots; causes heavy fouling with honeydew. Wide distribution. Polyphagous.
	Ischnaspis longirostris (black thread scale)	Hemiptera: Diaspididae	South Africa; The Americas; Oceania Papua New Guinea	Wide host range. High economic importance, occasionally a serious pest. Minute size and presence on all plant parts equate to high entry risk. As a parthenogenic species, it is likely to have high establishment potential.
	Pinnaspis aspidistrae (aspidistra scale)		South America; Japan; USA	Wide host range. High economic importance. Possibly parthenogenic. Occurs on all plant parts.
	Selenaspidus articulatus (West Indian red scale)		The Americas; Africa; Oceania	Wide host range. Economically important pest. Aggregates on fruit and leaves. High fecundity/ generation turnover. Chemical resistance. Minute size of insect reduces likelihood of detection.

[1] Brown, A.G.P. 1998. Pest Risk Analysis of Citrus Species for the Northern Australia Quarantine Strategy. A report prepared for the Australian Quarantine Inspection Service.

Priority Ranking	Pest	Classification	Distribution	Comments
High	*Ceroplastes brevicauda* (citrus wax scale)	Hemiptera: Coccidae	South Africa	On fruit, small and difficult to detect. High establishment potential. Alternate hosts available, including Australian native species. Spread by windborne crawlers and on nursery stock. High economic impact.
	Ceroplastes japonicus (tortoise wax scale)		Mediterranean; India; China; Korea; Japan.	Major pest in some countries. Polyphagous, with approximately 100 alternate hosts. High fecundity, tolerance to unfavourable conditions and crawlers disperse readily.
	Protopulvinaria pyriformis (heart-shaped scale)		North and South America; Mediterranean region; South Africa; Vietnam; Taiwan	Unlikely to be on harvested fruit. High economic impact. Wide host range. High fecundity and several overlapping generations per year in California. Parthenogenic. A serious pest in areas absent of natural enemies.
	Bactrocera carambolae (carambola fruit fly)	Diptera: Tephritidae	S.E. Asia, including Indonesia	High economic importance.
	Bactrocera caryeae		Southern India; Sri Lanka	High economic importance.
	Bactrocera dorsalis (Oriental fruit fly)		India, Sri Lanka to southern China, Taiwan; Thailand; Cambodia; Vietnam; Oceania	High economic importance.
	Bactrocera kandiensis		Sri Lanka	High economic importance.
	Bactrocera occipitalis		Philippines; Sabah; Brunei.	High economic importance.
	Bactrocera papayae (papaya fruit fly)		Thailand; Malaysia; Singapore; Indonesia; PNG	High economic importance.
	Bactrocera philippinensis		Philippines	High economic importance
	Bactrocera trivialis		Irian Jaya; Papua New Guinea	High economic importance
	Citripestis sagittiferella (citrus fruitborer)	Lepidoptera: Pyralidae	Thailand; Malaysia; Indonesia	High economic importance. Larvae attack fruit causing fruit drop. Adults are strong fliers. Illegal transport most likely pathway. Natural dispersal possible through Torres Strait.
	Amyelois transitella (navel orangeworm)		USA (California, Florida); Italy	Moderate economic importance. Wide host range. Illegal import more likely entry pathway. Strong dispersal capability. Small insects with high reproductive output. Fruit quality downgraded.
High	*Cryptoblabes gnidiella* (rindboring orange moth)		North & South America; Mediterranean & Middle East; Africa; South Asia (including Thailand); New Zealand	High economic importance. Polyphagous, wide distribution, high fecundity. Many possible entry pathways.
	Cryptophlebia leucotreta (false codling moth)	Lepidoptera: Tortricidae	Israel; Africa.	High economic importance. High fecundity, 5 or 6 generations per year. Unlikely to be capable of long distance dispersal. Polyphagous. Restricted to tropical and subtropical environments. Serious South African pest.

Priority Ranking	Pest	Classification	Distribution	Comments
High	*Diaprepes abbreviatus* (citrus weevil, West Indian weevil)	Coleoptera: Curculionidae	Europe, Western Hemisphere	Polyphagous, widely distributed species. Capable of serious economic damage to citrus (US $73 mil in Florida on Citrus lost in 1995). Species is highly fecund and may be carried on plant parts. Damage causes reduced vigour to host plant, may also encourage infection by *Phytophtora.*
Moderate	*Eutetranychus banksi* (Texas citrus mite)	Acarina: Tetranychidae	USA	Small and likely to escape detection on imported plant material. Moderate reproductive rate; numerous alternate hosts. High potential for spread, facilitated by wide host range. Wide distribution. Moderate economic impact. Heavy infestations combined with moisture stress, cold or windy conditions can result in injury to trees.
	Tetranychus cinnabarinus (carmine spider mite)		Europe, Asia, Africa, Brazil, Peru, Mexico, USA	This species is high risk for other crops but only has a moderate impact on citrus. Species may be recognised as belonging to part of the *T. urticae* complex.
	Eotetranychus kankitus (citrus yellow mite)		China	Occurs principally on shoots, leaves and young fruit, rather than mature fruit. Limited host range, but does occur on weedy species. Moderate economic impact; can cause fall of leaves, flowers and fruit. Mite population growth linked closely to abiotic factors.
	Caliothrips fasciatus	Thysanoptera: Thripidae	USA	High entry probability, a significant quarantine interception. High probability of spread,. A polyphagous species with high fecundity. Species overwinters on host. Cosmetic damage to fruit. . Serious pest in California on multiple crops prior to better crop management practices.
	Frankliniella insularis (blossum thrips)		Caribbean	Wide host and distribution range Small size may facilitate wind distribution. Economic impact unknown.
	Frankliniella bispinosa		USA; Central America	Wide host and distribution range Small size may facilitate wind distribution. Economic impact unknown.
	Empoasca distinguenda (green citrus leafhopper)	Hemiptera: Cicadellidae	Spain; Oriental region (Thailand, Vietnam, China); African region (South Africa)	Moderate economic impact. Wide host range. High spread potential as pest is active and can easily be moved around on wind currents.
	Aleurocanthus woglumi (citrus blackfly)	Hemiptera: Aleyrodidae	Thailand; Vietnam; China; Malaysia; Iran; South Africa; Italy;USA;Central America	Unlikely to be on harvested fruit. Possible entry through natural means (i.e. Torres Strait). High potential for establishment and spread, especially in warmer regions. High economic impact.
	Aleurodicus dugesii (giant whitefly)		USA	Several alternate hosts. Recent history of spread in North America. High economic impact. Suitable environmental conditions in Australia. High fecundity.
	Aleurothrixus floccosus (woolly whitefly)		USA; Mediterranean region; South Africa	High potential for establishment. High economic impact. Wide host range, wide geographic distribution, slow spread.
	Dialeurodes citrifolii (cloudy winged whitefly)	Hemiptera: Aleyrodidae	China; Vietnam; Japan; USA.	Unlikely to be on harvested and treated fruit. High establishment potential. Moderate economic impact. Heavy infestation may cause rapid deterioration and crop failure. Lives in similar environmental conditions to those in Australia.

Priority Ranking	Pest	Classification	Distribution	Comments
Moderate	*Pseudococcus comstocki* (Comstock's mealybug)	Hemiptera: Pseudococcidae	Central, S.E. Asia; The Americas	High entry potential: adults and crawlers likely to be on harvested fruit. High potential for establishment and spread. Crawlers dispersed on wind or nursery material. Moderate economic impact. High fecundity. Polyphagous. Overwinters on host.
	Dysmicoccus neobrevipes		S.E. Asia	High potential for entry and establishment; wide host range. Moderate economic impact; pest in Thailand in absence of natural enemies.
	Dysmicoccus nesophilus		Oceania	Wide host range and could be imported on fruit and flowers from the south Pacific region. High potential for establishment and spread. Economic impact probably no more than moderate.
	Maculicoccus malaitensis		Australasian: Kiribati, Papua New Guinea, Solomon Islands.	Wide host range and could be imported on fruit other than citrus imported from South Pacific region. High establishment and spread potential. Probably only moderate economic impact.
	Phenacoccus madeirensis (cassava mealybug)		The Americas; Africa; Mediterranean region	Wide host and distribution range. Moderate economic importance on citrus. Insignificant damage where natural predators exist.
	Pseudococcus citriculus		Asia; India; Paraguay	Species has a high risk of entry and is moderately polyphagous.
	Rastrococus iceryoides (mango mealybug)		SE Asia; East Africa	Wide host range. Moderate economic importance on citrus. High fecundity, high dispersal, moderate host range. May occur on fruit.
	Rastrococcus invadens (mango mealybug)		Central and West Africa; South east Asia	Wide host range. Occasionally a pest on citrus in Africa. High fecundity and dispersal ability.
	Unaspis yanonensis (arrowhead scale)	Hemiptera: Diaspididae	China; Japan; Korea.	Wide host range. Economic importance variable but can cause loss of fruit and plant dieback. Abiotic factors important to prevalence. Species overwinters on host. High reproductive ability, low juvenile mortality.
	Parlatoria ziziphis (black parlatoria scale, citrus scale)		Mediterranean; USA; South east Asia	Some reports of major economic impact. Unconfirmed occurrence in Australia (1964).
	Kilifia acuminata (acuminate scale)	Hemiptera: Coccidae	USA; Mediterranean; South America; Paupa New Guinea.	Moderate economic impact. Wide host range, moderate fecundity. Abiotic factors important to prevalence. Occurs on all plant parts, is photopostive. Minor citrus pest in Florida.
	Ceroplastes cirripediformis (barnacle scale)		USA, Western Hemisphere	Moderate economic impact, moderate host range.
	Ceroplastes rusci (fig wax scale)		Europe, Asia, Africa, Western Hemisphere.	Wide host range, wide geographic distribution. High fecundity. Dispersed by wind and mobile crawlers. Causes plant dieback and cosmetic damage to fruit.
	Helopeltis spp. (mosquito bugs)	Hemiptera: Miridae	S.E. Asia; PNG, Africa	Moderately high economic importance. Identity and distribution of species to be confirmed. Small insects, nocturnal fruit feeders, polyphagous, including weedy species. Causes damage to fruit, also allowing secondary infections (warts, blisters, scales, scabby fruit canker). High mobility. Possible entry through near neighbours (e.g. Torres Strait). High fecundity.
	Anoplophora chinensis (citrus trunk borer)	Coleoptera: Cerambycidae	China; Korea; Japan; Vietnam; Malaysia.	Attacks a wide range of orchard trees, principally citrus. May also be present in wooden crate packaging, and in illegal budwood. Most destructive cerambycid in China. Tree death is frequent in attacked groves.

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Moderate	*Bactrocera correcta* (guava fruit fly)	Diptera: Tephritidae	Pakistan; India; Nepal; Sri Lanka; Myanmar; Thailand; Southern China	Moderate economic importance.
	Bactrocera zonata (peach fruit fly)		Pakistan; India; Sri Lanka; Thailand; Vietnam; Mauritius; Egypt	Moderate economic importance.
	Ceratitis capitata (Mediterranean fruit fly)		?USA (California); ?China; ?Thailand; ?Vietnam; South Africa; ?Malaysia	Present in Western Australia but not in eastern Australia. Damaging pest, of high international quarantine importance.
	Ceratitis rosa (Natal fruit fly)		Africa; Mauritius; Reunion	High economic importance. A more serious pest than *C. capitata* in many warmer areas and with wide host range.
	Anastrepha spp.		USA; Central and South America	Some species with high economic impact generally, however citrus is not usually the preferred host. Species is not attracted to currently used lures.
	Prays citri (citrus flower moth)	Lepidoptera: Yponomeutidae	Europe, Asia, Africa.	Species is highly fecund and has a high entry risk. The species is restricted to citrus, and significant losses have been experienced on lemon crops.
	Bruchophagus muli (gall wasp)	Hymenoptera: Eurytomidae	Paupa New Guinea	Moderate economic impact. Species is restricted to limes. Difficult to control. Likely entry through natural means (Torres Strait).