Australian Government

Department of Agriculture, Fisheries and Forestry

Longan and lychee fruit from the People's Republic of China and Thailand

Final Import Risk Analysis Report

Part B

February 2004

CONTENTS

APPENDIX 1 – PEST CATEGORISATION FOR LONGAN AND LYCHEE FROM CHINA AND THAILAND

* Pathway (i.e. in association with mature, detached longan fruit or mature longan fruit on the panicle, or mature detached lychee fruit)

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
ARTHROPODS						
Acari (mites)						
Abacarus euphoriae Keifer [Acari: Eriophyidae]	Longan erineum mite	Thailand (DOA, 2003a)	No (Halliday, 1998)	Longan	No – Associated with leaves (DOA, 2003a)	No
Acaspina litchii Huang, Huang & Horng [Acari: Phytoseiidae]	Mite	China (Hong & Zhang, 1996)	No No records found	Lychee	No – Associated with leaves (Huang *et al*., 1989) CIQ (2000) claims not in China	No
Aceria dimocarpi Kuang, 1997 = *Eriophyes dimocarpi* Kuang [Acari: Eriophyidae]	Longan gall mite	China (He, 2001)	No (Halliday, 1998)	Longan	No – Associated with shoots, spikes and flowers. Has been recorded on developing, but not mature fruit. Possible vector of longan witches' broom disease (AQSIQ, 2003b; He, 2001)	No
Aceria litchii (Keiffer) = *Eriophyes litchii* (Keiffer) [Acari: Eriophyidae]	Litchi erinose mite, litchi hairy mite, litchi gall mite, litchi rust mite	China (Hong & Zhang, 1996) Thailand (Schuetz *et al*., 2002)	Yes (Halliday, 1998) Not in WA (DAWA, 2003a)	Longan Lychee	Yes – Feeds on leaves, twigs, foliar flushes and flower panicles. Has been recorded to feed on fruit causing visible damage and malformation (Kumar, 1992; Waite, 1999; Waite & Hwang, 2002)	Yes
Aceria longana Boczek & Knihinicki [Acari: Eriophyidae]	Longan erineum mite	Thailand (Waite & Hwang, 2002)	No (Halliday, 1998)	Longan	No – Associated with leaves, flowers and growing points (Ungasit *et al*., 1999; Waite & Hwang, 2002)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Agistemus exsertus Gonzalez-Rodriguez [Acari: Stigmaeidae]	Stigmaeid mite	China (PDI, 2000)	No (Halliday, 1998)	Lychee	No – Predatory mite (Hong & Zhang, 1996; Huang *et al*., 1989)	No
Amblyseius similiovalis Liang & Ke [Acari: Phytoseiidae]	Phytoseiid mite	China (Liang & Ke, 1983)	No (Halliday, 1998)	Lychee	No – Predatory mite (Liang & Ke, 1983)	No
Disella litchii Kuang & Feng [Acari: Nothopodinae]	Mite	China (Kuang & Feng, 1990)	No No records found	Lychee	No – Associated with leaves (Das & Chakrabati, 1982; Kuang & Feng, 1990)	No
Echinopsis fukiensis Fan & Chen [Acari: Raphignathidae]	Mite	China (Fan & Chen, 1996)	No (Halliday, 1998)	Longan	No – Associated with bark (Fan & Chen, 1996)	No
Epitrimerus dimocarpi Kuang & Hong 1989 [Acari: Eriophyidae]	Longan gall mite	China (Hong & Zhang, 1996)	No (Halliday, 1998)	Longan	No – Associated with leaves and new growth (Hong & Zhang, 1996)	No
Neoepitrimerus (*Neoleipothrix*) *alocasiae* Wei & Kuang, 1993 [Acari: Eriophyidae]	Gall mite	China (He *et al*., 1996)	No (Halliday, 1998)	Longan	No – Associated with buds, flowers and leaflets (He *et al*., 1996)	No
Oligonychus biharensis Hirst [Acari: Tetranychidae]	Cassava red mite	China (USDA, 1999) Thailand (CABI, 2002)	Yes (Halliday, 2000) Not present in WA (DAWA, 2003b)	Longan Lychee	No – Associated with leaves (DOA, 2003a, b)	No
Panonychus citri (McGregor) [Acari: Tetranychidae]	Citrus red mite, citrus red spider mite, red spider mite, purple mite	China (He, 2001)	Yes (Halliday, 1998) Not present in WA (AICN, 2001)	Lychee	No – Has been recorded as a minor pest in lychee orchards in China by He (2001), but no records of presence on lychee fruit (CABI, 2002; CIQ, 2000, Tan *et al*., 1998) Australia does not consider this mite to be a pest of lychee (BA, 2002, 2003)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Tetranychus spp. [Acari: Tetranychidae]	Mite	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
INSECTA (insects)						
Coleoptera (beetles)						
Adoretus complexus Burmeister [Coleoptera: Scarabaeidae]	Root grub	China (Sauco & Menini, 1989)	Yes (Houston, 1992) Not present in WA (DAWA, 2003a)	Lychee	No – Associated with roots (Sauco & Menini, 1989)	No
Adoretus compressus Weber [Coleoptera: Scarabaeidae]	Rose beetle	Thailand (Waterhouse, 1993)	No (Houston, 1992)	Longan	No – Associated with leaves (DOA, 2003a)	No
Adoretus hirsutus Ohaus [Coleoptera: Scarabaeidae]	White root grub	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Adoretus sinicus (Burmeister) [Coleoptera: Scarabaeidae]	Chinese rose beetle, root grub	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with roots and leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Adoretus tenuimaculatus Waterhouse [Coleoptera: Scarabaeidae]	Beetle	China (USDA, 1999)	No (Houston, 1992)	Longan	No – Adults feed on leaves, larvae feed on roots http://www.kcn.ne.jp/~tkawabe/kon-koganekoitya.htm	No
Anomala antiqua (Gyllenhal) [Coleoptera: Scarabaeidae]	Groundnut chafer	China (Tan *et al*. 1998)	Yes (Houston, 1992)	Longan Lychee		No
Anomala corpulenta Motschulsky [Coleoptera: Scarabaeidae]	Beetle	China (Waite, pers. comm., 2001)	No (Houston, 1992)	Lychee	No – Associated with leaves and new growth (Waite, pers. comm., 2001)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Anomala cuprea (Hope) [Coleoptera: Scarabaeidae]	Cupreous chafer	China (Waite, pers. comm., 2001)	No (Houston, 1992)	Lychee	No – Associated with leaves and new growth (Waite, pers. comm., 2001)	No
Anomala cupripes Hope [Coleoptera: Scarabaeidae]	Large green chafer beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Anomala ebenina Fairmaire [Coleoptera: Scarabaeidae]	Chafer beetle	China (USDA, 1999)	No (Houston, 1992)	Longan	No – Associated with leaves and new growth (USDA, 1999)	No
Anomala exoleta Faldermann [Coleoptera: Scarabaeidae]	Chafer beetle	China (USDA, 1999)	No (Houston, 1992)	Longan	No – Lives underground. Associated with soil (Sun, 1991; USDA, 1999; Xue & Guo, 1991)	No
Anomala expansa Bates [Coleoptera: Scarabaeidae]	Chafer beetle	China (USDA, 1999)	No (Houston, 1992)	Longan	No – Not associated with fruit (USDA, 1999)	No
Anomala pallida Fabricius [Coleoptera: Scarabaediae]	Beetle	Thailand (Waterhouse, 1993)	No (Houston, 1992)	Longan	No – Associated with leaves (DOA, 2000b)	No
Anomala varicolor Gyllenhal [Coleoptera: Scarabaeidae]	Beetle	China (Sauco & Menini, 1989)	No (Houston, 1992)	Lychee	No – Associated with leaves and new growth (Sauco & Menini, 1989)	No
Anoplophora almora Maulik [Coleoptera: Cerambycidae]	Beetle	China (CIQ, 2000)	No (CABI, 2002)	Longan	No – Associated with new stems (CIQ, 2000)	No
Anoplophora chinensis (Forster) [Coleoptera: Cerambycidae]	Black and white citrus longicorn beetle	China (Tan *et al*., 1998)	No (CABI, 2002)	Longan Lychee	No – Associated with roots, stems, trunks and branches (CIQ, 2000; Tan *et al*., 1997, 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Anoplophora malasiaca (Thompson) = *Anoplophora chinensi* var. *malasiaca* [Coleoptera: Cerambycidae]	White-spotted longicorn beetle	China (USDA, 1999)	No (CABI, 2002)	Longan Lychee	No – Associated with stems, bark, leaves, petioles and roots (CABI, 2002; http://www.fondazioneminoprio.it/biolomb/Insetti%20di%20nuova%20intro/Cartella%20Anoplophora/Anoplophora)	No
Apogonia cribricollis Burmeister [Coleoptera: Scarabaeidae]	Chafer beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with leaves, stems and roots (CABI, 2002)	No
Aristobia approximator [Coleoptera: Cerambycidae]	Long-horned beetle	Thailand (DOA, 2003a)	No (AICN, 2001)	Longan	No – Associated with branches (DOA, 2003a)	No
Aristobia horidura [Coleoptera: Cerambycidae]	Long-horned beetle	Thailand (DOA, 2003a)	No (AICN, 2001)	Longan	No – Associated with branches (DOA, 2003a)	No
Aristobia testudo (Voet) [Coleoptera: Cerambycidae]	Litchi longicorn beetle	China (Waite & Hwang, 2002)	No No records found	Longan Lychee	No - Associated with bark and stems (Ho *et al*., 1990; Waite & Hwang, 2002; Zhang, 1997)	No
Aspidomorpha sanctaecrucis Fabricius [Coleoptera: Chrysomelidae]	Tortoise beetle	Thailand (DOA, 2000b)	No (AICN, 2001)	Longan	No – Associated with leaves (Verma & Shrivastava, 1985)	No
Astathes episcopalis Chevrolet [Coleoptera: Cerambycidae]	Beetle	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Not associated with fruit (USDA, 1999)	No
Aulacophora almora Maulik [Coleoptera: Chrysomelidae]	Beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with new stems and new leaves (CIQ, 2000; Tan *et al*., 1998)	No
Aulacophora cattigarensis Weise [Coleoptera: Chrysomelidae]	Beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Aulacophora femoralis (Motschulsky) [Coleoptera: Chrysomelidae]	Cucurbit leaf beetle, orange broom galerucid	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Auloseryca migrorubra Busk. [Coleoptera: Scarabaeidae]	Beetle	China (Sauco & Menini, 1989)	No (Houston, 1992)	Lychee	No – Associated with leaves and new growth (Sauco & Menini, 1989)	No
Ceresium spp. [Coleoptera: Cerambycidae]	Longhorn beetle	China (Cavey, 1998)	No (genus present in NW Aust, SA, NSW, Qld, VIC) (McKeown 1947; Pollock, undated.)	Lychee	No – Associated with branches (Cavey, 1998)	No
Chrysochus chinensis Baly [Coleoptera: Chrysomelidae]	Beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Clitea fulva Chen [Coleoptera: Chrysomelidae]	Beetle	China (Tan *et al*., 1998)	No No records found	Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Colaphellus bowringi Baly [Coleoptera: Chrysomelidae]	Beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Euwallacea fornicatus Eichhoff = *Xyleborus fornicalus* [Coleoptera: Scolytidae]	Tea shot-hole borer, shot-hole borer of tea	China (He, 2001)	Yes (CABI, 2002) Not present in WA (DAWA, 2003a)	Lychee	No – Associated with twigs and stems (CABI, 2002)	No
Exolontha serrulata Gyllenhal [Coleoptera: Scarabaeidae]	Beetle	China (USDA, 1999)	No (Houston, 1992)	Longan	No – Associated with soil (May & Hamilton, 1989)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Formicomus braminus La Ferte Senectere [Coleoptera: Anthicidae]	Beetle	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with flowers (Armstrong & Drummond, 1986; USDA, 1999)	No
Henosepilachna vigintioctopunctata (Fabricius) = *Epilachna vigintioctopunctata* (Fabricius) [Coleoptera: Coccinellidae]	Hadda beetle, leaf-eating ladybird, 26-spotted ladybird	China (Tan *et al*., 1998)	Yes (Li, 1993)	Longan Lychee		No
Holotrichia ovata Chang [Coleoptera: Scarabaeidae]	White grub beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with roots (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Holotrichia plumbea planicollis Burmeister [Coleoptera: Scarabaeidae]	Beetle	China (Sauco & Menini, 1989)	No (Houston, 1992)	Lychee	No – Associated with leaves and roots (Sauco & Menini, 1989)	No
Holotrichia sauteri Moser [Coleoptera: Scarabaeidae]	Southern black chafer	China (Huang & Lin, 1987)	No (Houston, 1992)	Longan Lychee	No – Associated with flowers (Huang & Lin, 1987)	No
Hoplostomus chinensis Guer. [Coleoptera: Scarabaeidae]	Beetle	China (Sauco & Menini, 1989)	No (Houston, 1992)	Lychee	No – Associated with flowers (Allan, 1986; Keeping, 1984; Sauco & Menini, 1989)	No
Hypomeces squamosus Fabricius [Coleoptera: Curculionidae]	Green weevil, gold-dust beetle, gold-dust weevil	China (Tan *et al*., 1998) Thailand (Waterhouse, 1993)	No (Zimmerman, 1994)	Longan Lychee	No – Associated with leaves, roots and growing points (CIQ, 2000; DOA 2003a; Tan *et al*., 1998)	No
Lepidiota stigma Fabricius [Coleoptera: Scarabaeidae]	Sugarcane white grub	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with roots (CIQ, 2000; Tan *et al*., 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Lyctus brunneus (Stephens) [Coleoptera: Lyctidae]	Powderpost beetle	China (USDA, 1999)	Yes (AICN, 2001)	Longan		No
Maladera castanea (Arrow) [Coleoptera: Scarabaeidae]	Asiatic garden beetle, castaneus garden beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	Yes – Associated with new leaves and new stems. Has been recorded biting the pericarp of the fruit (AQSIQ, 2003b; CIQ, 2000; Tan *et al*., 1998, 1999)	Yes
Maladera spp. [Coleoptera: Scarabaeidae]	Chafer beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with new leaves and new stems (CIQ, 2000; Tan *et al*., 1998)	No
Metriona cirumdala Herbst [Coleoptera: Chrysomelidae]	Green tortoise beetle	China (Waite, pers. comm., 2001)	No No records found	Lychee	No – Associated with leaves (Waite, pers. comm., 2001)	No
Microtrichia cephalotes Burmeister [Coleoptera: Scarabaeidae]	Sugarcane chafer	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	No – Associated with leaves and new stems (CIQ, 2000; Tan *et al*., 1998)	No
Monolepta hieroglyphica Motschulsky [Coleoptera: Chrysomelidae]	Leaf feeding beetle, leaf beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Neomyllocerus hedini (Marshall) [Coleoptera: Curculionidae]	Weevil	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves and new stems (CIQ, 2000; Tan *et al*., 1998)	No
Nodina punctostrielata Fairmaire [Coleoptera: Chrysomelidae]	Leaf beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Oxycetonia jucunda Faldermann [Coleoptera: Scarabaeidae]	Flower chafer, citrus flower chafer	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	Yes – Larvae associated with roots, adults associated with flowers. Has been recorded on fruit (AQSIQ, 2003b; Tan *et al*., 1997)	Yes

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Phaedon brassicae Baly [Coleoptera: Chrysomelidae]	Daikon leaf beetle	China (Tan *et al*., 1998)	No No record found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Phyllotreta striolata Fabricius [Coleoptera: Chrysomelidae]	Cabbage flea beetle, striped flea beetle, turnip flea beetle, yellow striped flea beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves, roots and flowers (CIQ, 2000; Tan *et al*., 1998)	No
Platymycteropsis mandarinus Fairmaire [Coleoptera: Curculionidae]	Weevil	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves and new stems (CIQ, 2000; Tan *et al*., 1998, 1999)	No
Popillia mutans Newman [Coleoptera: Scarabaeidae]	Scarab beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	Yes – External feeding on flowers and leaves. Occasionally recorded feeding externally on fruit. Larvae feed on roots (AQSIQ, 2003a, b; CABI, 2002; Tan *et al*., 1998)	Yes
Popillia quadriguttata Fabricius [Coleoptera: Scarabaeidae]	Scarab beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	Yes – External feeding on flowers and leaves. Occasionally recorded feeding externally on fruit. Larvae feed on roots (AQSIQ, 2003a, b; CABI, 2002; Tan *et al*., 1998)	Yes
Potosia brevitarsis Lewis [Coleoptera: Scarabaeidae]	Flower beetle	China (He, 2001)	No (Houston, 1992)	Lychee	Yes – Mainly feeds on flowers. Has been recorded feeding on fruit (AQSIQ, 2003b) http://sklipkani.cz/malec/prot_pot.html	Yes

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Protaetia fusca (Herbst) [Coleoptera: Scarabaeidae]	Mottled flower scarab beetle, mango flower beetle	China (Tan *et al*., 1998)	Yes (Houston, 1992) Present in NSW, Qld and NT (AICN, 2003) Not present in WA (DAWA, 2003a)	Longan Lychee	Yes – Mainly associated with flowers and leaves. Has been reported on fruit in China (Tan *et al*., 1997) http://www.geocities.com/brisbane_beetles/SCARABAEIDEA.htm	Yes
Protaetia nitididorsis (Fairmaire) = *Cetonia esquiroli* Pouillaude [Coleoptera: Scarabaeidae]	Scarab beetle	China (Tan *et al*., 1998)	No (Houston, 1992)	Longan Lychee	Yes – Associated with flowers and leaves. Has been recorded feeding on fruit (AQSIQ, 2003b) http://www.geocities.com/brisbane_beetles/SCARABAEIDEA.htm	Yes
Sympiezomias citri Chao [Coleoptera: Curculionidae]	Grey citrus weevil	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Taiwania obtusata Boheman [Coleoptera: Chrysomelidae]	Beetle	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Ulomoides dermestoides Chevrolet [Coleoptera: Tenebrionidae]	Beetle	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Not associated with fruit (USDA, 1999)	No
Xylotrupes mniszechi Thomson (formerly under taxon *Xylotrupes gideon* (Linnaeus) = *Dynastes gideon* L. [Coleoptera: Scarabaeidae]	Elephant beetle, rhinoceros beetle	China (Tan *et al*., 1998; Rowland, 2003)	No (Houston, 1992; Rowland, 2003)	Longan Lychee	Yes – Adults feed externally on mature fruit, especially damaged fruit. Larvae feed on roots (FAO, 2002; Rogers & Blair, 1981)	Yes
Diptera (true flies; mosquitoes)						

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Bactrocera cucurbitae Coquillet [Diptera: Tephritidae]	Melon fly	China (CABI, 2002) Thailand (CABI, 2002)	No (CABI, 2002)	Lychee	Yes – Has been recorded on lychee in Taiwan and Hawaii (Fang & Chang, 1984; Waite & Hwang, 2002; Wen, 1985)	Yes
Bactrocera dorsalis (Hendel) [Diptera: Tephritidae]	Oriental fruit fly, Asian fruit fly, mango fruit fly	China (Liang *et al*., 1999) Thailand (Waterhouse, 1993)	No (CABI, 2002)	Longan Lychee	Yes – Feeds on fruit with damaged skin or rotting fruit (CABI, 2002; Liang *et al*., 1999)	Yes
Bactrocera spp. [Diptera: Tephritidae]	Fruit fly	China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Cecidomyiidae spp. [Diptera: Cecidomyiidae]	Gall midge	China (USDA, 1999)	No No records found	Longan	No – Associated with bark http://www.inra.fr/Internet/Produits/HYPPZ/RAVAGEUR/6resthe.htm	No
Litchiomyia chinensis Yang & Luo = *Dasyneura* spp. [Diptera: Cecidomyiidae]	Litchi gall midge, litchi leaf midge	China (He, 2001)	Yes (Naumann, 1993) Not present in WA (DAWA, 2003a)	Lychee	No – Associated with leaves (FAO, 2002)	No
Mayetiola spp. [Diptera: Cecidomyiidae]	Gall midge	China (Tan *et al*., 1999)	No. Only *M. destructor* in Australia (Martin, 1982)	Lychee	No – Associated with new leaves (CIQ, 2000; Tan *et al*., 1999; Yang & Luo, 1999)	No
Tephritidae spp. [Diptera: Tephritidae]	Fruit fly	China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Hemiptera (aphids; leafhoppers; mealybugs; phyllids; scales; true bugs; whiteflies						

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Aleurocanthus spiniferus Quaintance & Baker [Hemiptera: Aleyrodidae]	Spiny whitefly	China (USDA, 1999)	Yes (AICN, 2001) Not present in WA (DAWA, 2003a, b)	Longan	No – Associated with leaves and stems (CABI, 2002)	No
Aleurocanthus woglumi Ashby [Hemiptera: Aleyrodidae]	Citrus black fly, spiny citrus whitefly	China (Waite, pers. comm., 2001)	No (Martin, 1999)	Lychee	No – Associated with leaves http://creatures.ifas.ufl.edu/citrus/citrus_blackfly.htm	No
Aleurotuberculatus psidii (Singh) [Hemiptera: Aleyrodidae]	Whitefly	China (USDA, 1999)	No (CABI, 2002)	Longan	No – Associated with shoots (Wen & Lee, 1985)	No
Aonidiella orientalis (Newstead) [Hemiptera: Diaspididae]	Oriental red scale, Oriental scale, Oriental yellow scale	China (CABI, 1999)	Yes (AICN, 2001) Not present in WA (DAWA, 2003a)	Lychee	No – No records on longan or lychee fruit in China or elsewhere (AQSIQ 2003a, b; CIQ, 2000) CABI (2002) lists lychee as a secondary host	No
Aphis gossypii Glover [Hemiptera: Aphididae]	Melon aphid, cotton aphid	China (Waite, pers. comm., 2001)	Yes (AICN, 2001) Not present in WA (DAWA, 2003a)	Lychee	No – Associated with leaves, stems, growing points and inflorescences (CABI, 2002)	No
Aulacaspis longanae Chen [Hemiptera: Diaspididae]	Longan diaspidid scale	China (Chen *et al*., 1980)	No No records found	Longan Lychee	No – Associated with leaves of longan and lychee in China (AQSIQ, 2003a, b)	No
Aulacaspis spp. [Hemiptera: Diaspididae]	Hard scale	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Cantao ocellatus (Thunberg) [Hemiptera: Pentatomidae]	Shield bug	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Ceroplastes pseudoceriferus Green = *Ceroplastes ceriferus* (Fabricus) [Hemiptera: Coccidae]	Indian wax scale, Indian white wax scale, Japanese wax scale	China (Wen & Lee, 1986) Thailand (DOA, 2003a)	Yes (Qin & Gullan, 1994)	Longan Lychee		No
Ceroplastes rubens Maskell [Hemiptera: Coccidae]	Pink wax scale, red wax scale, ruby wax scale	China (Tan *et al*., 1997)	Yes (Qin & Gullan, 1994)	Longan Lychee		No
Cletus trigonus Thunberg [Hemiptera: Coreidae]	Rice slender bug	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Coccidae spp. [Hemiptera: Coccidae]	Scale	China (USDA, 1999)	No No records found	Longan	No – Associated with stems (USDA, 1999)	No
Coccus acutissimus (Green) [Hemiptera: Coccidae]	Banana-shaped scale	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems (USDA, 1999)	No
Coccus formicarii (Green) [Hemiptera: Coccidae]	Scale	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with leaves and stems of tea plants (Greathead, 1997)	No
Coccus hesperidum Linnaeus [Hemiptera: Coccidae]	Brown soft scale, common shield scale, soft brown scale, soft scale	China (Hu *et al*., 1992)	Yes (Waite & Hwang, 2002)	Lychee		No
Coccus longulus (Douglas) [Hemiptera: Coccidae]	Long brown scale, long shell scale, long shield scale, long soft scale	China (Tan *et al*., 1998)	Yes (Smith *et al*., 1997) Not present in WA (DAWA, 2003a)	Lychee	No – Associated with leaves and stems (DAWA, 2003a)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Coccus viridis Green [Hemiptera: Coccidae]	Green coffee scale, green scale, green shield scale, soft green scale	China (ScaleNet, 2001)	Yes (Waite & Elder, 2000) Not present in WA (DAWA, 2003a)	Longan Lychee	Yes – Has been recorded to infest leaves, twigs and fruit of lychee in Australia (Waite & Elder, 2000)	Yes
Cornegenapsylla sinica Yang & Li [Hemiptera: Psyllidae]	Longan psylla/psyllid	China (Yang & Li, 1982) Thailand (DOA, 2003a)	No (Yang & Li, 1982)	Longan	No – Associated with leaves. Possible vector of longan witches' broom disease (Chen *et al*., 1992; CIQ, 2000; Tan *et al*., 1997; Yang & Li, 1982; Zhan *et al*., 1999)	No
Cosmoscarta bispecularis White [Hemiptera: Cercopidae]		China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems (USDA, 1999)	No
Cryptotympana atrata Fabricius [Hemiptera: Cicadidae]		China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems (USDA, 1999)	No
Dalpada oculata (Fabricius) [Hemiptera: Pentatomidae]	Shield bug	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Dicyphococcus castilloae (Green) [Hemiptera: Coccidae]		China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems and leaves (Greathead, 1997; USDA, 1999)	No
Drepanococcus chiton [Hemiptera: Coccidae]	Wax scale	Thailand (DOA, 2003a)	No (AICN, 2001)	Longan	Yes – Associated with branches and fruit (DOA, 2003a)	Yes
Dysmicoccus neobrevipes Cockerell [Hemiptera: Pseudococcidae]	Gray pineapple mealybug	China (USDA, 1999) Thailand (Waterhouse, 1993)	No (CABI, 2002)	Longan	No – No record on longan or lychee (AQSIQ, 2003a, b; CABI, 2002; DOA, 2003a, b; ScaleNet, 2001; Kessing & Mau, 1992 http://www.extento.hawaii.edu/kbase/crop/Type/d_neobre.htm)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Empoasca vitis (Goethe, 1875) = *E. flavescens* (Fabricius) = *E. pirisuga* (Mura) [Hemiptera: Cicadellidae]	Smaller green leaf-hopper, green frogfly	China (Tan *et al*., 1998)	No (CABI, 2002)	Longan Lychee	No – Associated with leaves, stems and trunk (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Erthesina fullo (Thunberg) [Hemiptera: Pentatomidae]	Hong Kong shield bug	China (USDA, 1999)	No (CABI, 2002)	Longan	No – Associated with leaves and stems. May cause premature fruit drop (Song & Wang, 1993; USDA, 1999)	No
Erythroneura melia Kuoh [Hemiptera: Cicadellidae]	Bug	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997)	No
Eucalymnatus tessellatus (Signoret) [Hemiptera: Coccidae]	Tessellated scale	China (USDA, 1999)	Yes (AICN, 2001)	Longan	No – Associated with leaves http://creatures.ifas.ufl.edu/orn/scales/tessellated_scale.htm	No
Eurydema cingulatus [Hemiptera: Pentatomidae]	Bug	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Not associated with pathway (USDA, 1999)	No
Eutettix apicus Melichur [Hemiptera: Cicadellidae]	Bug	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997)	No
Ferrisia virgata (Cockerell) [Hemiptera: Pseudococcidae]	Striped mealybug, spotted mealybug, white tailed mealybug, guava mealybug	China (CABI, 1999)	Yes (Ben-Dov, 1994) Not present in WA (DAWA, 2003a)	Lychee	Yes – Feeds externally on fruit, leaves and shoots (CABI, 2002) http://www.ctahr.hawaii.edu/adap2/information/pubs/2000-18.pdf	Yes
Fiorinia pinicola Maskell [Hemiptera: Diaspididae]	Tea scale	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with leaves and stems (USDA, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Fiorinia theae Green [Hemiptera: Diaspididae]	Camellia scale, tea scale	China (USDA, 1999)	No (CABI, 2002)	Longan	No – Associated with leaves and stems (USDA, 1999) http://creatures.ifas.ufl.edu/orn/scales/tea_scale.htm	No
Geisha distinctissima Walker [Hemiptera: Flatidae]	Green broad-winged flattid	China (USDA, 1999)	No (CABI, 2002)	Longan	No – Sucks the sap of branches http://members.ytv.home.ne.jp/yt0077641/sub238.htm	No
Howardia biclavis (Comstock) [Hemiptera: Diaspididae]	Mining scale	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems (USDA, 1999)	No
Huechys sanguinea (DeGreer) [Hemiptera: Cicadidae]	Cicada	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems (USDA, 1999)	No
Hyperoncus lateritius (Westwood) [Hemiptera: Pentatomidae]	Shield bug	China (Tan *et al*., 1998)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Iassus indicus Lethierry [Hemiptera: Cicadellidae]	Leaf hopper	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997)	No
Icerya purchasi Maskell [Hemiptera: Margarodidae]	Cottony cushion scale	China (USDA, 1999)	Yes (AICN, 2001)	Longan		No
Icerya seychellarum Westwood [Hemiptera: Margarodidae]	Seychelles scale	China (USDA, 1999)	Yes (AICN, 2001) Not present in WA (DAWA, 2003a, b)	Longan	No – Sucks the sap of leaves and stems. Excretes honeydew on leaves and stems (CABI, 2002; DOA, 2003)	No
Icerya spp. [Hemiptera: Margarodidae]	Scale	Thailand (DOA, 2003)	No No records found	Longan	No – Associated with branches (DOA, 2003)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Idioscopus clypealis (Lethierry) [Hemiptera: Cicadellidae]	Mango leafhopper, blossom leafhopper	China (CABI, 2003) Thailand (Waterhouse, 1993)	Yes (NSW, 1999) No records in WA	Longan	No – Associated with leaves and inflorescences. Only recorded on mangoes. No evidence for association with longan or lychee in China or elsewhere (AQSIQ, 2003a, b; ScaleNet, 2001)	No
Kerria greeni (Chamberlin) [Hemiptera: Kerridae]	Green's lac insect	China (Li *et al*., 1997)	No (ScaleNet, 2001)	Longan	No – Associated with stems and branches http://www.icrisat.org/text/research/grep/homepage/grephomepage/archives/ppjoh.htm	No
Kerria lacca Kerr (Laccifer) [Hemiptera: Kerridae]	Lac insect	China (Subbarayudu & Ram, 1997) AQSIQ (2003b) claims not present in China Thailand (DOA, 2003b)	No (CABI, 2002)	Longan Lychee	No – Associated with stems and branches. (DOA, 2003b; Waite & Hwang, 2002) DOA (pers. comm., 2003) claims *K. lacca* has never been reported on longan or lychee fruit in Thailand	No
Kilifia acuminata (Signoret) [Hemiptera: Coccidae]	Mango shield scale	China (Nakahara, 1981)	No No records found	Lychee	No – Associated with stems (Ali, 1971; Ferris, 1950; Nakahara, 1981)	No
Lawana imitata Melichar [Hemiptera: Flattidae]	Flattid scale	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with branches and stems (CIQ, 2000)	No
Leptocentrus albolineatus Funkhouser [Hemiptera: Membracidae]	Leaf hopper	China (Tan *et al*., 1997)	No (Day & Fletcher, 1994)	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Leptocorisa acuta Thunberg [Hemiptera: Coreidae]	Rice seed bug, Asian rice bug, paddy bug, rice sapper	China (Tan *et al*., 1997)	Yes (Kay *et al*., 1993) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with leaves and twigs on longan and lychee in China. Associated with seeds of rice, but no records on longan or lychee fruit (CABI, 2002; Tan *et al*., 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Lindingaspis ferrisi McKenzie [Hemiptera: Diaspididae]	Hard scale	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with leaves (Swailem, 1974)	No
Metatachardia fukiensis Zhang [Hemiptera: Kerridae]	Lac insect	China (Zhang, 1993)	No No records found	Lychee	No – Associated with stems and branches (Tang, 1974; Zhang, 1993) CIQ (2000) claims not on lychee	No
Mictis tenebrosa Fabricius [Hemiptera: Coreidae]	Squash bug, leaf-footed bug	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Nezara antennata Scott [Hemiptera: Pentatomidae]	Green stink bug	China (Tan *et al*., 1997)	No No records found	Longan Lychee	Yes – Sucks the juice of young shoots, young leaves and young fruits. May be associated with mature fruit (AQSIQ, 2003b; Li *et al*., 2001; Tan *et al*., 1997)	Yes
Nipaecoccus spp. [Hemiptera: Pseudococcidae]	Mealybug	Thailand (DOA, 2003a)	No No records found	Longan	No – Not associated with the pathway (DOA, 2003a)	No
Nipaecoccus viridis (Newstead) = *Nipaecoccus vastator* (Maskell) [Hemiptera: Pseudococcidae]	Spherical mealybug, globular mealybug, cotton mealybug, coffee mealybug	China (Tan *et al*., 1998)	Yes (ScaleNet, 2001) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with stems (Tan *et al*., 1998) Not reported to be present in China by ScaleNet (2001) or CABI (2002)	No
Ochrochira camelina Kiritshenko [Hemiptera: Coreidae]	Squash bug, leaf-footed bug	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Parasaissetia nigra (Nietner) [Hemiptera: Coccidae]	Black coffee scale	China (Mamet, 1943)	Yes (PDI, 2000)	Lychee		No
Planococcus citri (Risso) [Hemiptera: Pseudococcidae]	Citrus mealybug	China (USDA, 1999)	Yes (AICN, 2001)	Longan		No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Planococcus litchi Cox [Hemiptera: Pseudococcidae]	Mealybug	China (Ben-Dov, 1994) Thailand (Ben-Dov, 1994)	No (Ben-Dov, 1994)	Lychee	Yes – Mealybugs are generally known to feed on fruit and are associated with the formation of sooty mould on the fruit surface (CABI, 2002)	Yes
Planococcus spp. [Hemiptera: Pseudococcidae]	Mealybug	China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Plautia crossota (Dallas) = *Plautia fimbriata* Fabricius [Hemiptera: Pentatomidae]	Brown-winged green bug	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems (USDA, 1999)	No
Pseudaonidia trilobitiformis Green [Hemiptera: Diaspididae]	Trilobite scale, armoured scale, hard scale	China (USDA, 1999)	No (CABI, 2002)	Longan	No – Not associated with fruit (USDA, 1999)	No
Pseudococcidae spp. [Hemiptera: Pseudococcidae]	Mealybug	China (USDA, 1999)	Yes (AICN, 2001)	Longan		No
Pseudococcus comstocki (Kuwana) [Hemiptera: Pseudococcidae]	Comstock's mealybug	China (CIE, 1975) on lychee	No (Ben-Dov, 1994)	Lychee	No – Not associated with *Litchi chinensis* (AQSIQ, 2003b; CABI, 2002; ScaleNet, 2001)	No
Pulvinaria polygonata Cockerell [Hemiptera: Coccidae]	Cottony citrus scale	China (USDA, 1999)	Yes (AICN, 2001) Not present in WA (AICN, 2001; DAWA, 2003b)	Longan	No – Associated with leaves http://www.horticultureworld.net/mango-india2.htm (USDA, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Pulvinaria psidii (Maskell) = *Chloropulvinaria psidii* (Maskell) [Hemiptera: Coccidae]	Green shield scale, guava mealy scale, guava scale mango scale	China (Waite & Hwang, 2002)	Yes (Menzel *et al*., 1988) Not present in WA (DAWA, 2003a)	Longan Lychee	Yes – Primarily infests leaves and twigs. May be present on the fruit if flowering panicles are infested, causing sooty mould formation (CABI, 2002; Waite & Elder, 1999; Waite & Hwang, 2002)	Yes
Pyrops candelaria Linnaeus = *Fulgora condelaria* Linnaeus; *Laternaria candalaria* (Linnaeus) [Hemiptera: Fulgoridae]	Lantern bug, longan leafhopper	China (Li *et al*., 1997)	No No records found	Longan Lychee	No – Associated with new stems (CIQ, 2000; Tan *et al*., 1998)	No
Pyrops lathburii (Kirby) [Hemiptera: Fulgoridae]	Bug	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with new stems (USDA, 1999)	No
Pyrops spinolae Westwood [Hemiptera: Fulgoridae]	Bug	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with new stems (USDA, 1999)	No
Rhynchocoris humeralis (Thunberg) [Hemiptera: Pentatomidae]	Spined fruit bug, spined fruit bug of citrus, citrus green stink bug	China (USDA, 1999) Thailand (Waterhouse, 1993)	No (CABI, 2002)	Longan	No – Pest of citrus - no evidence of association with longan or lychee (AQSIQ, 2003a; CABI, 2002; DOA, 2003a, b) http://agrolink.moa.my/doa/bdc/fruits/limau/man_pes.html	No
Ricania speculum (Walker) [Hemiptera: Ricaniidae]	Black leafhopper	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Riptortus linearis Fabricius [Hemiptera: Alydidae]	Legume pod bug	China (Tan *et al*., 1997, 1998)	Yes (Cassis & Gross, 2002) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with leaves of longans and lychees in China. Associated with seeds and pods of legumes, but not longan or lychee (CABI, 2002; Tan *et al*., 1997)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Saissetia coffeae Walker [Hemiptera: Coccidae]	Brown coffee scale, coffee helmet scale, helmet scale	China (Hu *et al*., 1992) Thailand (DOA, 2003a)	Yes (CABI, 2002)	Longan Lychee		No
Saissetia oleae (Olivier) [Hemiptera: Coccidae]	Black scale, black shield scale, brown olive scale, Mediterranean black scale, olive scale	China (Ali, 1971)	Yes (Smith *et al*., 1997)	Longan		No
Salurnis marginellus Guerin Meneville [Hemiptera: Flatidae]	Flattid scale	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with leaves and stems (Shun-Chern, 1989; USDA, 1999)	No
Solenostethium chinense Stål [Hemiptera: Scutelleridae]	Yellow-belly arctiid, shield backed bug	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Tartessus ferrugineus (Walker) [Hemiptera: Cicadellidae]	Leafhopper	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with stems (USDA, 1999)	No
Tenaphalara dimocarpi Yang & Li [Hemiptera: Psyllidae]	Psyllid	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Not associated with fruit (USDA, 1999)	No
Tessaratoma papillosa (Drury) [Hemiptera: Tessaratomidae]	Lychee/litchi stinkbug, litchi bug, leaf & twig sucking bug	China (Waite & Hwang, 2002) Thailand (Waite & Hwang, 2002)	No (Waite & Hwang, 2002)	Longan Lychee	Yes – Sucks the juice of young shoot, young leaves and young fruits. May be associated with mature fruit but usually causes premature drop. May be a vector of longan witches' broom disease (AQSIQ, 2003b; DOA, 2003a, b; FAO, 2002; Waite & Hwang, 2002)	Yes

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Thysanofiorinia nephelii Maskell [Hemiptera: Diaspididae]	Hard scale	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Associated with leaves and stems http://edis.ifas.ufl.edu/BODY_PI050	No
Unaspis yanonensis Kuwana [Hemiptera: Diaspididae]	Arrowhead scale, Oriental citrus scale	China (USDA, 1999)	No (CABI, 2002)	Longan	No – Not associated with fruit (CABI, 2002; USDA, 1999)	No
Hymenoptera (ants; bees; wasps)						
Anastatus japonicus Ashmead [Hymenoptera: Eupelmidae]	Egg parasite	China (Xin & Li, 1989)	No No records found	Longan Lychee	No – Egg parasite (Xin & Li, 1989)	No
Ooencyrtus spp. [Hymenoptera: Encyrtidae]	Egg parasite	China (Zhou & Xian, 1994)	No (CABI, 2000)	Longan	No – Egg parasite (Zhou & Xian, 1994)	No
Isoptera (termites)						
Coptotermes formosanus Shiraki [Isoptera: Rhinotermitidae]	Formosan subterranean termite	China (Li *et al*., 1997)	No (CABI, 2002)	Longan	No – Associated with stems and roots (Li *et al*., 1997)	No
Coptotermes spp. [Isoptera: Rhinotermitidae]	Subterranean termites	China (CABI, 1999)	Yes (AICN, 2001)	Lychee		No
Cryptotermes declivis Tsai & Chen [Isoptera: Kalotermitidae]	Termite	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Not associated with fruit (USDA, 1999)	No
Macrotermes barneyi Light [Isoptera: Termitidae]	Subterranean termite	China (USDA, 1999)	No (CABI, 2002)	Longan	No – Not associated with fruit (USDA, 1999)	No
Odontotermes formosanus Shiraki [Isoptera: Termitidae]	Subterranean termite	China (Waite, pers. comm., 2001)	No No records found	Lychee	No – Associated with roots (Waite, pers. comm., 2001)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Lepidoptera (butterflies; moths)						
Acanthoecia laminati Heylaerts [Lepidoptera: Psychidae]	Moth	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Not associated with fruit (USDA, 1999)	No
Acanthopsyche subteralbatus Hampson [Lepidoptera: Psychidae]	Case worm	China (Tan *et al*., 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with branches, stems and trunk (CIQ, 2000; Tan *et al*., 1998)	No
Achaea janata Linnaeus [Lepidoptera: Noctuidae]	Leaf-eating caterpillar	Thailand (Waterhouse, 1993)	Yes (Nielsen *et al*., 1996)	Lychee		No
Adoxophyes cyrtosema Meyrick [Lepidoptera: Tortricidae]	Citrus brown-banded tortrix, citrus leaf-roller	China (Waite & Hwang, 2002)	No (Nielsen *et al*., 1996)	Longan Lychee	Yes – Associated with fruit, flowers, leaves and new growth. External feeding on fruit (AQSIQ, 2003b; Waite & Hwang, 2002)	Yes
Adoxophyes orana Fisher von Röeslerstamm = *Adoxophyes fasciata* Walsh [Lepidoptera: Tortricidae]	Apple peel tortricid, smaller tea tortrix, summer fruit tortrix	China (Huang *et al*., 1997)	No (Nielsen *et al*., 1996)	Longan Lychee	Yes – Associated with fruit, flowers, leaves and new growth. External feeding on fruit (CABI, 2002; Huang *et al*., 1997)	Yes
Anisodes illepidaria Guenée [Lepidoptera: Geometridae]	Leaf-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with young leaves (DOA, 2000a; Kuroko & Lewvanich, 1993)	No
Anisozyga spp. [Lepidoptera: Geometridae]	Caterpillar	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Anthene emolus emolus Godart [Lepidoptera: Lycaenidae]	Ciliate blue	Thailand (Yutaka, 2001)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with flowers and young leaves (DOA, 2000a; Kuroko & Lewvanich, 1993)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Archips asiatica Walsingham [Lepidoptera: Tortricidae]	Leaf roller	China (Huang *et al*., 1997)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves. AQSIQ claims no record on longan or lychee. *Archips* spp. are reported as pests of leaves and flowers in Thailand (AQSIQ, 2003a; Kuroko & Lewvanich, 1993; USDA, 1999)	No
Archips machlopis Meyrick [Lepidoptera: Tortricidae]	Leaf roller	Thailand (DOA, 2000a)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (DOA, 2000a; Tuck, 1990)	No
Archips micacaena Walker [Lepidoptera: Tortricidae]	Leaf roller	Thailand (Waterhouse, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves, shoots and flowers (Kuroko & Lewvanich, 1993)	No
Archips tabescens Meyrick = *Homona tabescens* Meyrick [Lepidoptera: Tortricidae]	Leaf roller	China (Liu, 1964)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (CIQ, 2000) CIQ (2000) claims not on lychee	No
Ascotis selenaria imparata Walker [Lepidoptera: Geometridae]	Leaf-eating caterpillar, cotton geometrid	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves (DOA, 2000a, b; Kuroko & Lewvanich, 1993)	No
Asurida metaphae Hampson [Lepidoptera: Arctidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Attacus atlas (Linnaeus) [Lepidoptera: Saturniidae]	Atlas moth	China (CABI, 2002) Thailand (CABI, 2002)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (CABI, 2002)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Autoba abrupta Walker = *Eublemma abrupta* Walker [Lepidoptera: Noctuidae]	Flower caterpillar	Thailand (Waterhouse, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Not present in WA (DAWA, 2003b)	Longan Lychee	No – Associated with flowers (Kuroko & Lewvanich, 1993)	No
Autoba brachygonia Hampson = *Eublemma brachygonia* Hampson [Lepidoptera: Noctuidae]	Flower caterpillar	Thailand (Waterhouse, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with flowers (DOA, 2000a, b)	No
Autoba versicolor Hampson = *Eublemma versicolor* Hampson [Lepidoptera: Noctuidae]	Flower caterpillar	Thailand (Waterhouse, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Not present in WA (DAWA, 2003b)	Longan Lychee	No – Associated with flowers (DOA, 2003a)	No
Buzura suppressaria (Guenée) [Lepidoptera: Geometridae]	Tea looper	China (He, 2001)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (CABI, 2002) CIQ (2000) claims not on lychee	No
Cephonodes hylas hylas Linnaeus [Lepidoptera: Sphingidae]	Coffee hawk moth; bee hawk moth	Thailand (Kuroko & Lewvanich, 1993)	Yes (APPD, 2003) Not present in WA (DAWA, 2003b	Lychee	No – Feeds on leaves and flowers (Kuroko & Lewvanich, 1993)	No
Cerace stipatana Walker [Lepidoptera: Tortricidae]	Tortrix, borer	China (Huang *et al*., 1997)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Feed on leaves. No records on longan or lychee fruit (AQSIQ, 2003a, b)	No
Chalioides kondonis Matsumura [Lepidoptera: Psychidae]	Kondo white psychid	China (Tan *et al*., 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with branches, stems and trunk (CIQ, 2000; Tan *et al*., 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Cnesteboda celligera Meyrick [Lepidoptera: Tortricidae]	Leaf roller	China (USDA, 1999) Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves (DOA, 2000a; Kuroko & Lewvanich, 1993)	No
Comocritis albicapilla Moriuti [Lepidoptera: Oecophonidae]	Moth	China (Luo *et al*., 1998)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with bark (Liu & Xu, 1997; Luo *et al*., 1998)	No
Comostola laesaria Walker [Lepidoptera: Geometridae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996)	Longan	No – Associated with flowers (DOA, 2003a)	No
Conogethes punctiferalis Guenée = *Dichocrocis punctiferalis* [Lepidoptera: Pyralidae]	Yellow peach moth	China (Huang *et al*., 1997) Thailand (Waterhouse, 1993)	Yes (Nielsen *et al*., 1996) Not present in WA (DAWA, 2003a)	Longan	No – Associated with flowers (DOA, 2003a)	No
Conogethes spp. [Lepidoptera: Pyralidae]	Moth	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Conopomorpha litchiella Bradley [Lepidoptera: Gracillariidae]	Litchi leafminer	China (Waite & Hwang, 2002) Thailand (Waite & Hwang, 2002)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves and new growth (He, 2001; Waite & Hwang, 2002)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Conopomorpha sinensis Bradley [Lepidoptera: Gracillariidae]	Litchi fruit borer, litchi stem-end borer	China (Waite & Hwang, 2002) Thailand (Schuetz *et al*., 2002)	No (Nielsen *et al*., 1996)	Longan Lychee	Yes – Eggs are laid on fruit, leaves and shoots, and larvae penetrate the fruit. Adults feed externally on fruit Pest of longan and lychee (He, 2001; Waite & Hwang, 2002)	Yes
Cryptophlebia ombrodelta (Lower) [Lepidoptera: Tortricidae]	Litchi fruit moth, macadamia nut borer	China (Waite & Hwang, 2002) Thailand (Waite & Hwang, 2002)	Yes (Menzel *et al*., 1988)	Longan Lychee		No
Cryptothelea variegata Snellen [Lepidoptera: Psychidae]	Bagworm	China (Tan *et al*., 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with stems and trunk (CIQ, 2000; Tan *et al*., 1998)	No
Cyana coccinea Moore [Lepidoptera: Arctidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Dappula tertia Templeton [Lepidoptera: Psychidae]	Moth	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Not associated with fruit (USDA, 1999)	No
Darna diducta Snellen [Lepidoptera: Limacodidae]	Nettle caterpillar	Thailand (Waterhouse, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Dasychira mendosa Hübner = *Olene mendosa* Hübner [Lepidoptera: Lymantriidae]	Tussock caterpillar	Thailand (Kuroko & Lewvanich, 1993)	Yes (Herbison-Evans *et al*., 2003) Not present in WA (DAWA, 2003b)	Longan Lychee	No – Associated with leaves (Kuroko & Lewvanich, 1993)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Decadarchis leucopogon Meyrick [Lepidoptera: Tineidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with bark (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Deudorix epijarbas Moore = *Deudorix epijarbas amatius* Fruhstorfer [Lepidoptera: Lycaenidae]	Cornelian butterfly, fruit borer, grey lychee butterfly	China (Tan *et al*., 1998) Thailand (DOA, 2003a)	Yes (Nielsen *et al*., 1996; AICN, 2003) Not present in WA (DAWA, 2003a)	Longan Lychee	Yes – Eggs are laid on fruit and larvae bore inside, completely destroying the flesh and seed (DOA 2003b; Waite & Hwang, 2002)	Yes
Dudua aprobola (Meyrick) = *Argyroploce aprobola* (Meyrick, 1886); *Platypeplus aprobola* (Meyrick) [Lepidoptera: Tortricidae]	Brown tortrix, leaf roller, leaf-webber	China (Waite & Hwang, 2002) Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with leaves (Waite & Hwang, 2002)	No
Dudusa synopla Swinhoe [Lepidoptera: Notodontidae]	Leaf-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (DOA, 2000a; Kuroko & Lewvanich, 1993)	No
Dyspessa monticola Groum-Grshima [Lepidoptera: Cossidae]		China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Not associated with fruit (USDA, 1999)	No
Eboda cellerigera Meyrick [Lepidoptera: Tortricidae]	Tortrix	China (Tan *et al*., 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with new stems and new leaves (CIQ, 2000; He, 2001; Tan *et al*., 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Eudocima fullonia (Clerck) = *Othreis fullonia* [Lepidoptera: Noctuidae]	Fruit piercing moth, fruit sucking moth	China (Waite & Hwang, 2002) Thailand (Waite & Hwang, 2002)	Yes (Waite & Hwang, 2002)	Lychee Longan		No
Eudocima hypermnestra Stoll [Lepidoptera: Noctuidae]	Fruit piercing moth	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Not associated with pathway (USDA, 1999)	No
Eumeta japonica Heylaerts [Lepidoptera: Psychidae]	Japanese bagworm	China (Li *et al*., 1997)	No (Nielsen *et al*., 1996)	Longan	No – Associated with stems, shoots, twigs and leaves (Li *et al*., 1997)	No
Eumeta minuscula Butler [Lepidoptera: Psychidae]	Bag worm	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Associated with stems, shoots, twigs and leaves (USDA, 1999)	No
Eumeta variegata Snellen [Lepidoptera: Psychidae]	Bag worm	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Associated with stems, shoots, twigs and leaves (USDA, 1999)	No
Euproctis fraterna Moore [Lepidoptera: Lymantriidae]	Coffee hairy caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Euproctis scintillans (Walker) = *Porthesia scintillans* [Lepidoptera: Lymantriidae]	Hairy tussock caterpillar	China (Tan *et al*., 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves. Has been reported to chew developing fruit occasionally, causing premature drop (AQSIQ, 2003b; Tan *et al*., 1997, 1998) http://www.civil.soton.ac.uk/icuc/cd_icuc_ber_tamarind/content/tamarind/tamarind_manual_html/140.htm	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Euproctis taiwana Shiraki [Lepidoptera: Lymantriidae]	Tussock moth, yellow tailed moth	China (Li *et al*., 1997)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves, stems, flowers and shoots (He, 2001; Li *et al*., 1997; Su, 1985)	No
Euproctis varians (Walker) [Lepidoptera: Lymantriidae]	Moth/caterpillar	China (Tan *et al*., 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1997, 1998)	No
Gatesclarkeana idia Diakonoff [Lepidoptera: Tortricidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Feeds on flowers (Kuroko & Lewvanich, 1993)	No
Gelechiidae spp. [Lepidoptera: Gelechiidae]	Moth	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Gracillariidae spp. [Lepidoptera: Gracillariidae]	Leafminer	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Gymnoscelis imparatalis Walker [Lepidoptera: Geometridae]	Leaf-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996	Longan Lychee	No – Associated with young leaves (Kuroko & Lewvanich, 1993)	No
Hedylepta barcalis Walker [Lepidoptera: Pyralidae]	Leaf-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (DOA, 2000a; Kuroko & Lewvanich, 1993)	No
Hemithea tritonaria Walker [Lepidoptera: Geometridae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with young leaves and flowers (DOA, 2000b; Kuroko & Lewvanich, 1993)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Homodes bracteigutta Walker [Lepidoptera: Noctuidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Not present in WA (DAWA, 2003b)	Longan	No – Feeds on rambutan fruit No evidence to show association with longan (Kuroko & Lewvanich, 1993)	No
Homona coffearia (Nietner) [Lepidoptera: Tortricidae]	Coffee tortrix, tea flushworm, tea tortrix, leafroller	China (Waite & Hwang, 2002) Thailand (Waite & Hwang, 2002)	No (Waite & Hwang, 2002)	Longan Lychee	No – Associated with leaves. DOA (pers. comm., 2003) claims that *H. coffearia* has never been recorded on longan or lychee fruit. AQSIQ (2003a) reports that *H. coffearia* may attack young fruit in China, but causes premature drop (CABI, 2002; Kuroko & Lewvanich, 1993)	No
Homona difficilis Meyrick [Lepidoptera: Tortricidae]	Leaf roller	Thailand (Waite & Hwang, 2002)	No (Waite & Hwang, 2002)	Longan Lychee	No – Associated with leaves (DOA, 2000a, b; Kuroko & Lewvanich, 1993)	No
Homona spp. [Lepidoptera: Tortricidae]	Leaf roller	China (USDA, 1999)	No No records found	Longan	No – Associated with leaves (USDA, 1999)	No
Hypatima longanae Tan *et al*. [Lepidoptera: Gelechiidae]	Twig borer	China (Tan *et al*., 1997, 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Primarily associated with leaves, trunk and shoots. May attack young fruit, but causes premature drop (AQSIQ, 2003a; Punnaiah & Devaprasad, 1996; Tan *et al*., 1998)	No
Hypolycaena erylus himavantus [Lepidoptera: Lymantriidae]	Leaf-eating caterpillar	Thailand (DOA, 2003a)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2003a)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Hyposidra talaca Walker [Lepidoptera: Geometridae]	Leaf-eating looper	Thailand (Waterhouse, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Present in WA (DAWA, 2003b)	Longan Lychee	No – Associated with leaves (Kuroko & Lewvanich, 1993)	No
Idonauton apicalis Walker [Lepidoptera: Limacodidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Indarbela tetraonis Moore [Lepidoptera: Metarbelidae]	Bark borer	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Associated with bark and trunk (Rao, 1992; Sharma & Kumar, 1986)	No
Ischyja manlia Cramer [Lepidoptera: Noctuidae]	Leaf-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Not present in WA (DAWA, 2003b)	Lychee	No – Associated with leaves (Kuroko & Lewvanich, 1993)	No
Jodis subtractata Walker [Lepidoptera: Geometridae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with flowers (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Kunugia basidiscata (Holloway) [Lepidoptera: Lasiocampidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Feeds on leaves (Kuroko & Lewvanich, 1993)	No
Lobescia genialis Meyrick [Lepidoptera: Lymantriidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with flowers (DOA, 2000b; Kuroko & Lewvanich, 1993)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Lymantria dispar Linnaeus [Lepidoptera: Lymantriidae]	Asian gypsy moth	China (CABI, 2002)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves and inflorescences (CABI, 2002)	No
Lymantria xylina Swindoe [Lepidoptera: Lymantriidae]	Moth	China (He, 2001)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (He, 2001)	No
Mahasena oolona Sonan [Lepidoptera: Psychidae]		China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (Shiao, 1981; USDA, 1999)	No
Miresa albipuncta Herrich-Schaffer [Lepidoptera: Limacodidae]	Leaf-eating caterpillar, slug caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (DOA, 2000a; Meshram *et al*., 1991)	No
Miresa fulgida Wilemam [Lepidoptera: Euoleidae?]	Slug caterpillar	China (He, 2001)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (He, 2001; Meshram *et al*., 1991)	No
Neostauropus alternus Walker [Lepidoptera: Notodontidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Nygmia fraterna [Lepidoptera: Lymantriidae]	Leaf-eating caterpillar	Thailand (DOA, 2003a)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves (DOA, 2003a; Kuroko & Lewvanich, 1993)	No
Oenospila flavifuscata Walker [Lepidoptera: Geometridae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Not present in WA (DAWA, 2003b)	Longan	No – Associated with leaves (Kuroko & Lewvanich, 1993)	No
Olethreutes leucaspis (Meyrick) [Lepidoptera: Tortricidae]	Leafroller, moth	China (Tan *et al*., 1998)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with new stems and new leaves (Liu, 1964; Tan *et al*., 1998, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Olethreutinae spp. [Lepidoptera: Tortricidae]	Olethreutine moth	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Orgyia postica (Walker) = *Notolophus australis posticus* Walker [Lepidoptera: Lymantriidae]	Cocoa tussock moth, small tussock moth	China (Tan *et al*., 1998) Thailand (Waterhouse, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves (CIQ, 2000; DOA, 2000a, b; He, 2001)	No
Orgyia turbata Butler [Lepidoptera: Lymantriidae]	Tussock moth	China (Tan *et al*., 1998) Thailand (DOA, 2003a)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves (CIQ, 2000; DOA, 2003a; Tan *et al*., 1998)	No
Oxyodes scrobiculata (Fabricius, 1775) [Lepidoptera: Noctuidae]	Leaf-eating looper	China (Waite & Hwang, 2002) Thailand (Schuetz *et al*., 2002)	Yes (Nielsen *et al*., 1996) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with new twigs, new leaves and flowers (Kuroko & Lewvanich, 1993; Tan *et al*., 1997)	No
Parasa lepida (Cramer) [Lepidoptera: Limacodidae]	Blue striped nettlegrub, nettle caterpillar	China (CABI, 1999) Thailand (Waterhouse, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves of lychee (CABI, 2002; DOA, 2003b; Ooi *et al*., 2002)	No
Phycitinae spp. [Lepidoptera: Pyralidae]	Moth	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Pingasa chlora Stoll [Lepidoptera: Geometridae]	Flower-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Not present in WA (DAWA, 2003b)	Lychee	No – Associated with leaves (Kuroko & Lewvanich, 1993)	No
Pingasa pseudoterpnaria gracilis Prout [Lepidoptera: Geometridae]	Moth	China (Tan *et al*., 1997)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with new leaves (CIQ, 2000; Tan *et al*., 1998)	No
Pingasa ruginaria Guenée [Lepidoptera: Geometridae]	Flower-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with flowers and young leaves (DOA, 2000a, b; Kuroko & Lewvanich, 1993)	No
Polydesma boarmoides Guenée [Lepidoptera: Noctuidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996) Unknown distribution Not present in WA (DAWA, 2003b)	Lychee	No – Associated with leaves (Kuroko & Lewvanich, 1993)	No
Prodenia litura (Fabricius) [Lepidoptera: Noctuidae]	Moth	China (Tan *et al*., 1998)	Yes (Nielsen *et al*., 1996)	Lychee		No
Pseudonirmides cyanopasta Hampson [Lepidoptera: Limacodidae]	Leaf-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves (DOA, 2000a, b; Kuroko & Lewvanich, 2003)	No
Pyraustinae spp. [Lepidoptera: Pyralidae]	Hong Kong moth	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Rapala pheretima petosiris Hewitson [Lepidoptera: Lycaenidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with flowers (DOA, 2000a; Kuroko & Lewvanich, 1993)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Rapala varuna orseris Hewitson [Lepidoptera: Lycaenidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with flowers and young leaves (DOA, 2000a; Kuroko & Lewvanich, 1993)	No
Sauris interruptaria Moore [Lepidoptera: Geometridae]		China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Not associated with fruit (USDA, 1999)	No
Selepa celtis Moore, 1858 [Lepidoptera: Noctuidae]	Hairy caterpillar	China (Tan *et al*., 1998) Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996)	Longan Lychee		No
Setora sinensis Moore = *Setora postornata* (Hampson) [Lepidoptera: Limacodidae]	Moth	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Associated with trunk and branches (Sun, 1985; USDA, 1999)	No
Sphecosesia litchivora [Lepidoptera: Sesiidae]	Moth	China (Yang *et al*., 2003)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with bark (Yang *et al*., 2003)	No
Spodoptera litura Fabricius [Lepidoptera: Noctuidae]	Cotton leaf-worm	China (USDA, 1999)	Yes (Nielsen *et al*., 1996)	Longan		No
Squamura dea Swinhoe = *Arbela dea* Swinhoe; *Indarbela dea* Swinhoe [Lepidoptera: Metarbelidae]	Bark borer, litchi bark caterpillar, metarbelid borer	China (Waite & Hwang, 2002)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with stems, bark and trunk (CIQ, 2000; Waite & Hwang, 2002; Xu & Yang, 1992)	No
Squamura discipuncta (Wileman) = *Arbela baibarana* Matsumura; *Indarbela baibarana* [Lepidoptera: Metabelidae]	Bark borer, litchi stem borer, stem borer, metarbelid borer	China (Li *et al*., 1997; Waite & Hwang, 2002)	No (Nielsen *et al*., 1996)	Longan	No – Associated with stems (Li *et al*., 1997; Waite & Hwang, 2002)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Statherotis discana (Felder & Rogenhofer) [Lepidoptera: Tortricidae]	Litchi leaf roller	China (Meyrick, 1911) Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with young leaves (DOA, 2003b; Kuroko & Lewvanich, 1993)	No
Statherotis leucaspis Meyrick [Lepidoptera: Tortricidae]	Leaf roller	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with young leaves (DOA, 2003a, b; Kuroko & Lewvanich, 1993)	No
Stauropus alternus (Walker) [Lepidoptera: Notodontidae]	Lobster caterpillar	China (Li *et al*., 1997)	No (Nielsen *et al*., 1996)	Longan	No – Associated with leaves and flowers (Li *et al*., 1997)	No
Stauropus persimilis Butler [Lepidoptera: Notodontidae]	Moth	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Not associated with fruit (USDA, 1999)	No
Sympis rufibasis Guenée [Lepidoptera: Noctuidae]	Moth/caterpillar	China (Tan *et al*., 1998) Thailand (Kuroko & Lewvanich, 1993)	Yes (Nielsen *et al*., 1996) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with flowers and leaves (Kuroko & Lewvanich, 1993; Tan *et al*., 1997)	No
Tarsolepis elephantorum Banginger [Lepidoptera: Notodontidae]	Leaf-eating caterpillar	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Lychee	No – Associated with leaves (DOA, 2000a; Kuroko & Lewvanich, 1993)	No
Thalassodes falsaria Prout [Lepidoptera: Geometridae]	Leaf-eating looper	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with leaves and flowers (DOA, 2000a, b; Kuroko & Lewvanich, 1993)	No
Thalassodes proquadraria Inouce [Lepidoptera: Geometridae]	Leaf-eating looper	China (USDA, 1999)	No (Nielsen *et al*., 1996)	Longan	No – Not associated with fruit (USDA, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Thalassodes quadraria Guenée [Lepidoptera: Geometridae]	Caterpillar	China (Tan *et al*., 1998) Thailand (DOA, 2003a, b)	Yes (Balciunas *et al*., 1993) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with leaves and twigs (Kuroko & Lewvanich, 1993; Tan *et al*., 1997)	No
Zeuzera coffeae Nietner [Lepidoptera: Cossidae]	Coffee leopard moth, coffee moth borer, red branch borer red coffee borer	China (Waite & Hwang, 2002) Thailand (Waterhouse, 1993)	No (Nielsen *et al*., 1996)	Longan Lychee	No – Associated with branches, bark, stems and trunk (CIQ, 2000; DOA, 2003a; He, 2001; Waite & Hwang, 2002)	No
Zurobata vacillans Walker [Lepidoptera: Noctuidae]	Moth	Thailand (Kuroko & Lewvanich, 1993)	No (Nielsen *et al*., 1996)	Longan	No – Associated with young leaves (DOA, 2000b; Kuroko & Lewvanich, 1993)	No
Orthoptera (crickets; grasshoppers; katydids)						
Brachytrupes portentosus Litchenstein [Orthoptera: Gryllidae]	Big brown cricket	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Lives in soil (Barwal, 1985; USDA, 1999)	No
Chondracris rosea (De Geer) [Orthoptera: Acrididae]	Citrus locust, cotton locust	China (Tan *et al*., 1997)	No (CABI, 2002)	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Choroedocus violaceipes Miller [Orthoptera: Acrididae]	Grasshopper	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Holochlora japonica (Brunner von Wattenwyl) [Orthoptera: Tettigoniidae]	Katydid	China (USDA, 1999)	No (AICN, 2001)	Longan	No – Not associated with fruit (USDA, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Holochlora nawae Matsumura & Shiraki [Orthoptera: Tettigoniidae]	Katydid	China (Tan *et al*., 1997)	No No records found	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Locusta migratoria manilensis (Meyen) [Orthoptera: Acrididae]	Oriental migratory locust, migratory locust	China (Tan *et al*., 1998)	No Subspecies not recorded (AICN, 2001)	Longan Lychee	No – Associated with leaves (CIQ, 2000; Tan *et al*., 1998)	No
Tarbinskiellus portentosus (Litchenstein) [Orthoptera: Gryllidae]	Large brown cricket	China (Li *et al*., 1997)	No Orthoptera species online	Longan	No – Associated with roots (Li *et al*., 1997)	No
Thysanoptera (thrips)						
Ernothrips lobatus [Thysanoptera: Thripidae]	Thrips	Thailand (Masumoto & Okajima, 2002)	No (Mound, 2003)	Lychee	No – Associated with inflorescences (DOA, 2003b)	No
Phlaeothripidae spp. [Thysanoptera: Phlaeothripidae]	Thrips	China (USDA, 1999)	No (Mound, 2003)	Longan	No – Not associated with fruit (USDA, 1999)	No
Scirtothrips dorsalis Hood [Thysanoptera: Thripidae]	Castor thrips, chilli thrips, strawberry thrips, tea yellow thrips	China (Waite & Hwang, 2002) Thailand (DOA, 2003a)	Yes (AICN, 2001) Not present in WA (DAWA, 2003a)	Longan Lychee	No – Associated with leaves, growing points and inflorescences (CABI, 2002)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Selenothrips rubrocinctus (Giard) [Thysanoptera: Thripidae]	Red-banded thrips, cacao thrips, cocoa thrips	China (He, 2001)	Yes (AICN, 2001)	Lychee		No
Stenchaetothrips fusca (Moulton) [Thysanoptera: Thripidae]	Thrips	China (USDA, 1999)	No (Mound, 2003)	Longan	No – Not associated with fruit (USDA, 1999)	No
Thripidae spp. [Thysanoptera: Thripidae]	Thrips	China (USDA, 1999)	No No records found	Longan	No – Not associated with fruit (USDA, 1999)	No
Thrips coloratus [Thysanoptera: Thripidae]	Thrips	Thailand (DOA, 2003a, b)	Yes (Mound, 2003) Not present in WA (DAWA, 2003b)	Longan Lychee	No – Associated with flowers (DOA, 2003a, b)	No
Thrips hawaiiensis [Thysanoptera: Thripidae]	Thrips	Thailand (Waterhouse, 1993)	Yes (Mound, 2003)	Lychee	No – Associated with inflorescences (DOA, 2003b)	No
NEMATODA						
Aorolaimus helicus Sher [Tylenchida: Hoplolaiminae]	Nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a, b)	No
Aphelenchoides bicaudatus Imamura [Tylenchida, Aphelenchoididae]	Nematode	China (Yin *et al*., 1994a)	Yes (Siddiqui, 1976)	Lychee		No
Aphelenchoides fragariae Christie [Tylenchida, Aphelenchoididae]	Nematode	China (USDA, 1999)	Yes (McLeod *et al*., 1994)	Longan		No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Aphelenchus avenae Bastian [Apelendiida: Aphelenchidae]	Nematode	China (Yin *et al*., 1994a)	Yes (McLeod *et al*., 1994)	Lychee		No
Aphelenchus maximus Das [Apelendiida: Aphelenchidae]	Nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Aphelenchus sparsus Thorne & Malek [Apelendiida: Aphelenchidae]	Nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Clavilenchus similis Thorne & Malek [Tylenchida: Criconematidae]	Nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Criconemella De Grisse & Loof [Tylenchida: Criconematidae]	Ring nematode	China	Yes, genus present (Reay, 1985) Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (CABI, 2002)	No
Criconemoides annulatum Taylor = *Criconemella annulatum* [Tylenchida: Criconematidae]	Ring nematode	China (USDA, 1999)	NoNo records found	Longan	No – Associated with roots (CABI, 2002)	No
Criconemoides complexus Jairajpuri [Tylenchida: Criconematidae]	Ring nematode	China (Liu & Feng, 1995)	No No records found	Lychee	No – Associated with roots (Liu & Feng, 1995; Yang *et al*., 1992)	No
Criconemoides macrodorum Taylor = *Criconemella macrodorum* [Tylenchida: Criconematidae]	Ring nematode	China (USDA, 1999)	No No records found	Longan	No – Associated with roots (CABI, 2002)	No
Discocriconemella limitanea (Luc) De Grisse & Loof [Tylenchida: Criconematidae]	Nematode	China (Yin *et al*., 1994a)	Yes Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Helicotylenchus californicus Sher Tylenchida: Hoploaimidae]	Spiral nematode	China (Yin *et al*., 1994a)	Yes Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Helicotylenchus concavus Roman [Tylenchida: Hoploaimidae]	Spiral nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Helicotylenchus crenacauda Sher [Tylenchida: Hoplolaimidae]	Spiral nematode	China (Liu & Zhang, 1999)	No No records found	Longan	No – Associated with roots (Liu & Zhang, 1999)	No
Helicotylenchus digonicus Perry in Perry, Darling & Thorne [Tylenchida: Hoploaimidae]	Spiral nematode	China (Yin *et al*., 1994a)	Yes Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Helicotylenchus dihystera (Cobb) Sher [Tylenchida: Hoploaimidae]	Common spiral nematode	China (Liu & Zhang, 1999)	Yes Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Liu & Zhang, 1999)	No
Helicotylenchus exallus Sher [Tylenchida: Hoploaimidae]	Spiral nematode	China (Yin *et al*., 1994a) Thailand (Ratanaprapa and Boonduang, 1975)	Yes Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Helicotylenchus multicinctus Golden [Tylenchida: Hoploaimidae]	Nematode	China (USDA, 1999)	Yes (McLeod *et al*., 1994)	Longan		No
Helicotylenchus spp. [Tylenchida: Hoploaimidae]	Spiral nematode	China (Yin *et al*., 1994a)	Yes (Menzel *et al*., 1988)	Lychee		No
Hemicriconemoides birchfieldi [Tylenchida: Criconematidae]	Ring nematode	China (Zhang, 1998)	No No records found	Lychee	No – Associated with roots (Zhang, 1998)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Hemicriconemoides fujianensis [Tylenchida: Criconematidae]	Ring nematode	China (Zhang, 1998)	No No records found	Lychee	No – Associated with roots (Zhang, 1998)	No
Hemicriconemoides litchi Edward & Misra [Tylenchida: Criconematidae]	Ring nematode	China (Zhang, 1998)	No No records found	Lychee	No – Associated with roots (Liu & Feng, 1995; Zhang, 1998)	No
Hemicriconemoides mangiferae Sidiqqi [Tylenchida: Criconematidae]	Ring nematode	China (Liu & Zhang, 1999)	Yes Not present in WA (McLeod *et al*., 1994)	Longan Lychee	No – Associated with roots (Liu & Zhang, 1999)	No
Lelenchus spp. [Tylenchida: Tylenchidae]	Nematode	China (Yin *et al*., 1994a)	No. Only *L. leptosoma* (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Longidorus litchii Xu [Dorylaimida: Longidoridae]	Needle nematode	China (Xu & Cheng, 1992)	No No records found	Lychee	No – Associated with roots (PDI, 2000; Xu & Cheng, 1992)	No
Macroposthonia xenoplax (Raski) De Grisse & Loof = *Criconemella xenoplex* [Tylenchida: Criconematidae]	Ring nematode	China (Yin *et al*., 1994a)	Yes (McLeod *et al*., 1994)	Lychee		No
Meloidogyne incognita (Kofoed & White) [Tylenchida: Meloidogynidae]	Root knot nematode	China (Huang, pers. comm., 2000)	Yes (McLeod *et al*., 1994)	Lychee		No
Meloidogyne spp. [Tylenchida: Meloidogynidae]	Root knot nematode	China (Yang *et al*., 1992)	Yes (McLeod *et al*., 1994)	Lychee		No
Paratrichodorus nanus (Allen) Siddiqi [Triplonchida: Trichodoridae]	Stubby root nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Paratrichodorus porosus (Allen) Sidiqqi [Triplonchida: Trichodoridae]	Stubby-root nematode	China (Liu & Zhang, 1999)	Yes (CABI, 2002)	Longan		No
Paratylenchus elachistus Steiner [Tylenchida: Paratylenchidae]	Nematode	China (Yin *et al*., 1994a)	Yes Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Paratylenchus veruculatus Wu [Tylenchida: Paratylenchidae]	Pin nematode	China (Liu & Zhang, 1999)	No No records found	Longan	No – Associated with roots (Liu & Zhang, 1999)	No
Pratylenchus brachyurus (Godfrey) Filipjev & Schuurmans Stekhoven [Tylenchida: Pratylenchidae]	Root lesion nematode, meadow nematode, smooth headed nematode	China (Yin *et al*., 1994a)	Yes (McLeod *et al*., 1994)	Lychee		No
Pratylenchus coffeae (Zimmerman) Filipjev & Steckh [Tylenchida: Pratylenchidae]	Banana root nematode, root lesion nematode	China (Liu & Zhang, 1999)	Yes (McLeod *et al*., 1994)	Longan Lychee		No
Pratylenchus pratensis (de Man) Filipjev [Tylenchida: Pratylenchidae]	Root lesion nematode	China (Liu & Zhang, 1999)	Yes Not present in WA (McLeod *et al*., 1994)	Longan	No – Associated with roots (Liu & Zhang, 1999)	No
Pratylenchus spp. [Tylenchida: Pratylenchidae]	Root lesion nematode	China	Yes (McLeod *et al*., 1994)	Lychee		No
Rotylenchulus reniformis (Linford & Oliveira) [Tylenchida: Rotylenchulidae]	Reniform nematode	China (Yin *et al*., 1994a)	Yes (McLeod *et al*., 1994; Sauer, 1981)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Scutylenchus quadrifer Andrássy Siddiqi [Tylenchida: Merliniinae]	Nematode	China (Yin *et al*., 1994a)	No (CABI IP, 1985)	Lychee	No – Associated with roots (Yin *et al*., 1994a, b)	No
Trichodorus monhystera Allen [Triplonchida: Trichodoridae]	Stubby root nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Trichodorus pakistanensis Siddiqi [Triplonchida: Trichodoridae]	Stubby root nematode	China (Liu & Zhang, 1999)	No No records found	Longan	No – Associated with roots (Liu & Zhang, 1999)	No
Tylenchorhynchus annulatus (Cassidy) Golden [Tylenchida: Belonolamidae]	Stunt nematode, pin nematode	China (Liu & Zhang, 1999)	Yes Not present in WA (McLeod *et al*., 1994)	Longan	No – Associated with roots (Liu & Zhang, 1999)	No
Tylenchorhynchus claytoni Steiner [Tylenchida: Belonolaimidae]	Stunt nematode, tobacco stunt nematode	China (Yin *et al*., 1994a)	Yes Not present in WA (McLeod *et al*., 1994)	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Tylenchorhynchus leviterminalis Siddiqi, Mukherjee & Dasgupta [Tylenchida: Belonolamidae]	Stunt nematode	China (Liu & Zhang, 1999)	No No records found	Longan	No – Associated with roots (Liu & Zhang, 1999)	No
Tylenchorhynchus nudus Allen [Tylenchida: Belonolaimidae]	Stunt nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Tylenchulus semipenetrans Cobb [Tylenchida: Tylenchulidae]	Citrus root nematode, root nematode, citrus nematode	China (Yin *et al*., 1994a)	Yes (McLeod *et al*., 1994)	Lychee		No
Tylenchus butteus Thorne & Malek [Tylenchida: Tylenchulidae]	Citrus root nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Tylenchus cylindricollis Thorne & Malek [Tylenchida: Tylenchulidae]	Citrus root nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Tylenchus exiguus de Man [Tylenchida: Tylenchulidae]	Citrus root nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Tylenchus fusiformis Thorne & Malek (Siddiqi) [Tylenchida: Tylenchulidae]	Citrus root nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Tylenchus parvissimus Thorne & Malek [Tylenchida: Tylenchulidae]	Citrus root nematode	China (Yin *et al*., 1994a)	No No records found	Lychee	No – Associated with roots (Yin *et al*., 1994a)	No
Xiphinema americanum Cobb [Dorylaimida: Longidoridae]	Dagger nematode, tobacco ringspot nematode	China (Yin *et al*., 1994a)	Yes (McLeod *et al*., 1994)	Lychee	CIQ (2000) claims not on lychee No – Associated with roots (Siddiqi, 1973)	No
Xiphinema insigne Loos [Dorylaimida: Longidoridae]	Dagger nematode	China (Liu & Zhang, 1999)	Yes (McLeod *et al*., 1994)	Longan	No – Associated with roots (Liu & Zhang, 1999)	No
PATHOGENS						
ALGAE						
Cephaleuros virescens Kunsze [Chroolepidales: Chroolepidaceae]	Algal spot	China (CABI, 2002) Thailand (DOA, 2003a, b)	Yes (Coates *et al*., 2002) No records in WA	Longan Lychee	No – Associated with leaves (DOA, 2003a, b)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
FUNGI						
Ascochyta longan C.F. Zhang & P.K. Chi [Mitosporic fungi]	Leaf spot	China (Zhang & Qi, 1996)	No No records found	Longan	No – Associated with leaves (Zhang & Qi, 1996)	No
Ascochyta spp. [Mitosporic fungi]	Leaf spot	China (USDA, 1999)	No No records found on longan	Longan	No – Not associated with pathway (USDA, 1999)	No
Aspergillus niger Van Tiegh [Mitosporic fungi: Hyphomycetes]	Aspergillus ear rot, fruit rot, collar rot	China (Huang & Scott, 1985) Thailand (Farr *et al*., 1989)	Yes (Farr *et al*., 1989)	Lychee		No
Aspergillus restrictus G. Sm. [Mitosporic fungi: Hyphomycetes]	Fruit rot	China (Huang & Scott, 1985)	Yes (APPD, 2003; Farr *et al*., 1989) Not present in WA (DAWA, 2003a)	Lychee	Yes – Causes rot of fruit (DAWA, 2003a)	Yes
Aspergillus spp. [Mitosporic fungi: Hyphomycetes]	Fruit rot	China (USDA, 1999)	Yes (Shivas, 1989)	Longan		No
Asterina heliciae Yamam. [Dothideales:Asterinaceae		China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Botryodiplodia spp. [Mitosporic fungi: Coelomycetes]	Collar rot	China (Jiang, 1997)	Yes (Tongdee *et al*., 1982) Not present in WA on longan (DAWA, 2003a)	Longan	Yes – *Botryodiplodia* spp. are associated with fruit (CABI, 2002)	Yes
Botryodiplodia theobromae Pat. [Mitosporic fungi: Coelomycetes]	Fruit rot	Thailand (Lim & Sangchote, 2000)	Yes (NCOF, 1998; Simmonds *et al*., 1966)	Lychee		No
Brachysporium spp. [Mitosporic fungi]	Die-back	Thailand (DOA, 2000b)	No No records found	Longan	No – Associated with twigs (DOA, 2000b)	No
Capnodium ramosum [Dothidiales: Capnodeaceae]	Sooty mould	Thailand (DOA, 2003a)	No (APPD, 2003)	Longan	Yes – Sooty mould growth on fruit, flowers, leaves (DOA, 2003a; Ungasit *et al*., 1999)	Yes
Chaetothyrium echinulatum Yamam [Dothideales: Chaetothyriacea]	Sooty mould	China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Chaetothyrium sawadai Yamam [Dothideales: Chaetothyriacea]	Sooty mould	China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Colletotrichum gloeosporioides = *Glomerella cingulata* (Penz.) Penz. & Sacc. [Phyllachorales: Phyllachoraceae]	Leaf blight, blossom blight, anthracnose, brown blight, fruit rot	China (CIQ, 2000) Thailand (Lim & Sangchote, 2000)	Yes (Coates *et al*., 2002)	Lychee		No
Colletotrichum spp. [Phyllachorales: Phyllachoraceae]		China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Coniothyrium litchii P.K. Chi & Z.D. Jiang [Mitosporic fungi]	Canker	China (USDA, 1999)	No No records found	Longan	Yes – Associated with fruit (USDA, 1999)	Yes
Corynespora cassiicola (Berk. & M.A. Curtis) C.T. Wei [Mitosporic fungi: Hyphomycetes]	Leaf spot	Thailand (DOA, 2003b)	Yes Not present in WA (APPD, 2003)	Lychee	No – Associated with inflorescences (DOA, 2003b)	No
Corethropsis spp. [Mitosporic fungi]		China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Curvularia lunata (Wakk.) Boedijin [Mitosporic fungi]	Fruit rot	Thailand (DOA, 2000a)	Yes (Shivas, 1989)	Lychee		No
Cylindrocladiella peruviana (Bat., Bez., & Herrera) [Mitosporic fungi: Hyphomycetes]	Cylindrocladiella disease	China (CIQ, 2000)	No No records found	Longan	Yes – Associated with fruit (CIQ, 2000)	Yes
Dimeriella dendrocalami Sawada & Yamam [Dothidiales: Parodiopsidaceae]		China (Tai, 1979)	No No records found	Lychee	No – Associated with leaves (Sawada, 1959; Tai, 1979)	No
Diplodia spp. [Mitosporic fungi]	Seed rot	Thailand (DOA, 2000b)	No No records found	Longan	No – Not associated with the pathway	No
Fusarium solani (Mart.) [Mitosporic fungi]	Dry rot	China (USDA, 1999)	Yes (Shivas, 1989)	Longan		No
Glomerella cingulata (Stonem.) Spauld. & Schr. [Phylachorales: Phylachoraceae]	Anthracnose	China (USDA, 1999)	Yes (Shivas, 1989)	Longan		No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Hexagonia apiaria (Pers.) Fr. [Poriales: Coreiolaceae]		China (USDA, 1999)	No No records found	Longan	Yes – *Hexagonia* spp. are polypores and are wood-rotting fungi but may affect panicles (Farr *et al*., 1989; USDA, 1999)	Yes
Hexagonia heteropora (Montogne) Lmazaki [Poriales: Coreiolaceae]		China (USDA, 1999)	No No records found	Longan	Yes – *Hexagonia* spp. are polypores and are wood-rotting fungi but may affect panicles (Farr *et al*., 1989; USDA, 1999)	Yes
Leptosphaeria guiyuan C.F. Zhang & P.K. Chi [Dothideales: Leptosphaericaceae]	Leaf spot	China (Zhang & Qi, 1996)	No No records found	Longan	No – Associated with leaves (Zhang & Qi, 1996)	No
Leptosphaeria longan C.F. Zhang & P.K. Chi [Dothideales: Leptosphaericaceae]	Leaf spot	China (Zhang & Qi, 1996)	No No records found	Longan	No – Associated with leaves (Zhang & Qi, 1996)	No
Marssonia euphoriae C.F. Zhang & P.K. Chi [Mitosporic fungi: Hyphomycetes]	Brown leaf spot	China (Zhang & Qi, 1996)	No No records found	Longan	No – Associated with leaves (Zhang & Qi, 1996)	No
Meliola camelliae (Catt.) Sacc. [Meliolales: Meliolaceae]	Sooty mould	China (USDA, 1999)	Yes Not present in WA (APPD, 2003)	Longan	No – Not associatedt with pathway (USDA, 1999)	No
Meliola capensis (K. & C.) Thiess var. euphoriae Hangsf. [Meliolales: Meliolaceae]	Sooty mould	China (Hu *et al*., 1986)	No No records found	Longan	No – Associated with leaves (Hu & Lu, 1989; Jiang, 1989; Zhang & Zhang, 2000)	No
Meliola eupaniae-majoris [Meliolales: Meliolaceae]	Sooty mould	Thailand (DOA, 2003b)	No No records found	Lychee	Yes – Sooty mould growth on fruit, flowers and leaves (DOA, 2003b; Ungasit *et al*., 1999)	Yes
Meliola euphoriae [Meliolales: Meliolaceae]	Sooty mould	Thailand (DOA, 2003a)	No (APPD, 2003)	Longan	Yes – Sooty mould growth on fruit and leaves (DOA, 2003a)	Yes

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Meliola nepheliicola Stev. *et* Rold. [Meliolales: Meliolaceae]	Sooty mould	China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Neocapnodium tanakae (Shirai *et* Hara) [Dothideales: Capnodiaceae]	Sooty mould	China (USDA, 1999)	No No records found	Longan	Yes – Sooty mould growth on leaves, fruit and stems. Appears as a superficial black growth (MAFF, 1990)	Yes
Oospora spp. [Mitosporic fungi]		China (USDA, 1999)	Yes (Shivas, 1989)	Longan		No
Penicillium spp. [Mitosporic fungi]	Mould	China Cosmopolitan (Farr *et al*., 1989)	Yes (CABI, 2002)	Longan		No
Peronophythora litchii Chen ex Ko *et al*. [Pythiales: Pythiaceae]	Litchi brown blight	China (Coates *et al*., 2000) Thailand (DOA, 2003b)	No (CABI, 2002)	Lychee	Yes – Formation of black or brown lesions on fruit, flowers, inflorescences and peduncle (CABI, 2002; Coates *et al*., 2000)	Yes
Pestalotia funerea Desm. = *Pestalotiopsis funerea* [Mitosporic fungi: Coelomycetes]	Leaf spot	China (USDA, 1999)	No No records found	Longan	No – Associated with leaves (DOA, 2000b; USDA, 1999)	No
Pestalotia spp. [Mitosporic fungi: Coelomycetes]	Leaf spot	Thailand (DOA, 2000b)	Yes – genus present (Shivas, 1989)	Longan	No – Associated with leaves DOA, 2000b)	No
Pestalotiopsis pauciseta (Sacc.) Y.X. Chen =*Pestalotia pauciseta* [Mitosporic fungi: Coelomycetes]	Leaf blight	China (Zhang & Qi, 1996; USDA, 1999) Thailand (DOA, 2000a, b)	No No records found	Longan Lychee	No – Associated with leaves (DOA, 2000a, b; Zhang & Qi, 1996)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Pestalotiopsis spp. [Mitosporic fungi: Coelomycetes]	Leaf spot	Thailand (DOA, 2003a)	No No records found	Longan	No – Associated with leaves (DOA, 2003a)	No
Phaeosaccardinula javanica (Zimm.) Yamamoto [Ascomycota: Caetothyriaceae]	Sooty mould	China (Tai, 1979)	No No records found	Lychee	No – Associated with leaves (Eriksson & Yue, 1985; Tai, 1979)	No
Phellinus noxius (Corner) G. Cunn. [Hymenochaetales: Hymenochaetaceae]	Root rot; wood rot	China (Ann *et al*., 2002)	Yes (Bolland, 1984) Not present in WA (DAWA, 2003a)	Longan Lychee	No – *Phellinus* spp. cause root rot and heart rot (Ann *et al.,* 2002)	No
Phellinus williamsii (Murr.) Pat. [Hymenochaetales: Hymenochaetaceae]	Root rot	China (USDA, 1999)	No (APPD, 2003)	Longan	No – *Phellinus* spp. cause root rot and heart rot (CABI, 2002)	No
Phialophora spp. [Ascomycota: Magnaporthaceae]	Leaf spot	Thailand (DOA, 2000b)	No Genus present, no records found on longan (APPD, 2003)	Longan	No – Associated with leaves (DOA, 2000b)	No
Phlyctaena spp. [Mitosporic fungi]		China (USDA, 1999)	Yes (Shivas, 1989)	Longan		No
Phomopsis guiyuan C.F. Zhang & P.K. Chi [Diaporthales: Valsaceae]	Grey leaf blight	China (Zhang & Qi, 1996)	NoNo records found of this species, *Phomopsis* spp. present	Longan	No – Associated with leaves (Zhang & Qi, 1996)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Phomopsis longanae Chi & Jiang [Diaporthales: Valsaceae]	Fruit blotch, branch canker	China (Lin & Chi, 1992)	No No records found of this species, *Phomopsis* spp. present	Longan Lychee	Yes – Associated with fruit, bark, stems and twigs (Lin & Chi, 1992)	Yes
Phyllosticta spp. [Mitosporic fungi]	Leaf spot	Thailand (DOA, 2000b)	No No records found on longan. Genus on many hosts including Sapindaceae plants (APPD, 2003)	Longan	No – Associated with leaves (DOA, 2000b)	No
Phytophthora capsici Leonian [Pythiales: Pythiaceae]	Leaf blight	Thailand (DOA, 2003a)	Yes (APPD, 2003)	Longan		No
Phytophthora palmivora (E.J. Butler) E.J. Butler [Pythiales: Pythiaceae]	Leaf blight, fruit rot Root rot	Thailand (CABI, 2002)	Yes (APPD, 2003; Simmonds, 1966) Not present in WA (DAWA, 2003b)	Longan Lychee	Yes – Causes fruit, stem and root rot (CABI, 2002; DOA, 2003a, b) No—Associated with root rot	Yes
Pseudoperonospora spp. [Peronosporales: Peronosporaceae]		China (USDA, 1999)	No, genus present. No records on Sapindaceae (APPD, 2003)	Longan	Yes – Associated with fruit (USDA, 1999)	Yes
Rhizopus arrhizus A. Fischer (R. oryzae) [Mucorales: Mucoraceae]	Fruit rot	China (Huang & Scott, 1985)	Yes (APPD, 2003)	Lychee	Yes – Post-harvest disease of fruit (CABI, 2002)	No

Pest	Common name	Distribution	Present in Australia	Host	Pathway association * – Comment/ Reference	Consider further
Skierka nephelii [Uredinales: incertae sedis]	Rust	(Thailand (DOA, 2003b)	No No records found	Lychee	No – Associated with leaves (DOA, 2003b)	No
Trametes spp. [Poriales: Coriolaceae]		China (USDA, 1999)	Yes (APPD, 2003)	Longan		No
Triposporiopsis spinigera (Hoehn) Yamam. [Dothideales: Capnodiaceae]		China (USDA, 1999)	No No records found	Longan	No – Forms on leaves http://www.ag168.com/news/epaper03_%E8%93%AE%E9%9C%A7%E7%85%A4%E7%97%85.htm	No
Uredo euphoriae Pat. [Uredinales: incertae sedis]	Rust	China (USDA, 1999)	No No records found	Longan	No – Not associated with pathway (USDA, 1999)	No
Uredo nephelii [Uredinales: incertae sedis]	Rust	China (Hirasuka *et al*., 1992)	No No records found	Lychee	No – Associated with leaves (Hiratsuka & Chen, 1991; Hiratsuka *et al*., 1992)	No
Yeast (unidentified)	Yeast	Thailand (DOA, 2000b)	No No records found	Longan	Yes – Associated with fruit (DOA, 2000b)	Yes
VIRUSES						
Virus	Leaf cure	Thailand (DOA, 2000a)	No No records found	Lychee	No – Associated with leaves (DOA, 2000a)	No
DISEASES OF UNKNOWN AETIOLOGY						
LWBD Mycoplasma-like/Filamentous virus? Organism	Longan witches' broom disease	China (Chen *et al*., 1992, 1996; CIQ, 2000; Coates *et al*., 2000) Thailand (DOA, 2000b)	No No records found	Longan Lychee	Yes – Associated with flowers, leaves, seeds, budwood, shoots (Chen *et al*., 1992, 1996; CIQ, 2000; Zee *et al*., 1998)	Yes

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APPENDIX 2 – POTENTIAL FOR ESTABLISHMENT AND ECONOMIC CONSEQUENCES

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
ARTHROPODS						
Acari (mites)						
Aceria litchii (Keiffer) = *Eriophyes litchii* (Keiffer) [Acari: Eriophyidae]	Litchi erinose mite, litchi hairy mite, litchi gall mite, litchi rust mite	Feasible	Narrow host range (CABI, 2002). High reproductive rate and may be dispersed by wind (Waite & Hwang, 2002).	Not significant	Already established in Queensland, but not present in Western Australia (DAWA, 2003) or other states (APPD, 2003). Only known hosts are longan and lychee (CABI, 2002), which are not commercially produced in Western Australia (DAWA, 2003)	No
INSECTA (insects)						
Coleoptera (beetles)						
Maladera castanea (Arrow) [Coleoptera: Scarabaeidae]	Asiatic garden beetle, castaneus garden beetle	Feasible	Moderate host range. Adults are highly mobile so may spread in the PRA area.	Significant	May cause superficial damage to the fruit, resulting in loss of quality. Can cause damage to turf and be very destructive in large numbers.	Yes

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Oxycetonia jucunda Faldermann [Coleoptera: Scarabaeidae]	Flower chafer, citrus flower	Feasible	Moderate host range including *Malus, Pyrus* and *Citrus* sp. Adults are highly mobile so may spread in the PRA area.	Significant	May cause superficial damage to the fruit, resulting in loss of quality.	Yes
Popillia mutans Newman [Coleoptera: Scarabaeidae]	Scarab beetle	Feasible	Adults are highly mobile so may spread in the PRA area.	Significant	May cause superficial damage to the fruit, resulting in loss of quality.	Yes
Popillia quadriguttata Fabricius [Coleoptera: Scarabaeidae]	Scarab beetle	Feasible	Adults are highly mobile so may spread in the PRA area. Wide host range.	Significant	May cause superficial damage to the fruit, resulting in loss of quality. Affects a number of important horticultural and agricultural crops (Lee *et al.* 2002).	Yes
Potosia brevitarisis Lewis [Coleoptera: Scarabaeidae]	Flower beetle	Feasible	Adults are highly mobile so may spread in the PRA area.	Significant	May cause superficial damage to the fruit, resulting in loss of quality.	Yes
Protaetia fusca (Herbst) [Coleoptera: Scarabaeidae]	Mottled flower scarab beetle, mango flower beetle	Feasible	Adults are highly mobile so may spread in the PRA area.	Significant	May cause superficial damage to the fruit, resulting in loss of quality.	Yes
Protaetia nitididorsis (Fairmaire) = *Cetonia esquiroli* Pouillaude [Coleoptera: Scarabaeidae]	Scarab beetle	Feasible	Adults are highly mobile so may spread in the PRA area.	Significant	May cause superficial damage to the fruit, resulting in loss of quality.	Yes

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Xylotrupes mniszechi Thomson (formerly under taxon *Xylotrupes gideon* (Linnaeus) = *Dynastes gideon* L. [Coleoptera: Scarabaeidae]	Elephant beetle, rhinoceros beetle	Feasible	Moderate host range. Adults are highly mobile so may spread in the PRA area.	Significant	May cause superficial damage to the fruit, resulting in loss of quality.	Yes
Diptera (true flies; mosquitoes)						
Bactrocera cucurbitae Coquillet [Diptera: Tephritidae]	Melon fly	Feasible	Wide host range (Allwood *et al*., 1999). Dispersed by infected fruit and adult flight (Fletcher, 1989). Strong flyer – adults can fly 50-100 km (Fletcher, 1989).	Significant	Primary economic impact would result from quarantine restrictions imposed by important domestic and foreign export markets, rather than from direct yield losses from infested fruit.	Yes
Bactrocera dorsalis (Hendel) [Diptera: Tephritidae]	Oriental fruit fly, Asian fruit fly, mango fruit fly	Feasible	Wide host range (Allwood *et al*., 1999; Tsuruta *et al*., 1997). Dispersed by infected fruit and adult flight (Fletcher, 1989). Strong flyer – adults can fly 50-100 km (Fletcher, 1989).	Significant	Primary economic impact would result from quarantine restrictions imposed by important domestic and foreign export markets, rather than from direct yield losses from infested fruit.	Yes

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Hemiptera (aphids; leafhoppers; mealybugs; psyllids; scales; true bugs; whiteflies)						
Coccus viridis Green [Hemiptera: Coccidae]	Green coffee scale, green scale, green shield scale, soft green scale	Feasible	Wide host range (ScaleNet, 2001). High reproductive rate (Waite & Hwang, 2002).	Significant	Can infest a wide range of plant species. Therefore, has potential to cause economic damage if introduced.	Yes
Drepanococcus chiton [Hemiptera: Coccidae]	Wax scale	Feasible	Wide host range (ScaleNet, 2001). High reproductive rate (Waite & Hwang, 2002).	Significant	Can infest other host species eg. carambola and guava. Therefore, has potential to cause economic damage if introduced.	Yes
Ferrisia virgata (Cockerell) [Hemiptera: Pseudococcidae]	Striped mealybug, spotted mealybug, white tailed mealybug, guava mealybug	Feasible	Wide host range (Ben-Dov, 1994) and high reproductive rates (Mau & Kessing, 2000).	Significant	Can infest a wide range of plant species. Therefore, has potential to cause economic damage if introduced.	Yes

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Nezara antennata Scott [Hemiptera: Pentatomidae]	Green stink bug	Feasible	Wide host range (Panizzi *et al*., 2000). Adapted to tropical and subtropical climates. Adults and nymphs are mobile.	Significant	Pierces fruit and sucks juice. May cause superficial damage on fruit resulting in reduced quality.	Yes
Planococcus litchi Cox [Hemiptera: Pseudococcidae]	Mealybug	Feasible	Narrow host range (Ben-Dov, 1994) but high reproductive rates (Mau & Kessing, 2000).	Significant	Causes loss of fruit quality, Therefore, has the potential to cause economic damage if introduced.	Yes
Pulvinaria psidii (Maskell) = *Chloropulvinaria psidii* (Maskell) [Hemiptera: Coccidae]	Green shield scale, guava mealy scale, guava scale mango scale	Feasible	Wide host range (ScaleNet, 2001). High reproductive rate (Mau & Kessing, 2000).	Significant	Can infest a wide range of plant species. Therefore, has potential to cause economic damage if introduced.	Yes
Tessaratoma papillosa (Drury) [Hemiptera: Tessaratomidae]	Lychee/litchi stinkbug, litchi bug, leaf & twig sucking bug	Feasible	Wide host range (Panizzi *et al*., 2000). Adapted to tropical and subtropical climates. Adults and nymphs are mobile.	Significant	Causes yield losses of 20-30% and 80-90% if infestations are heavy. Causes superficial damage to fruit and fruit drop (CABI, 2002).	Yes

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Lepidoptera (butterflies; moths)						
Adoxophyes cyrtosema Meyrick [Lepidoptera: Tortricidae]	Citrus brown-banded tortrix, citrus leaf-roller	Feasible	Wide host range and high reproductive rate (Waite & Hwang, 2002).	Significant	Larvae damage fruit by chewing large holes that usually cause fruit rot (CABI, 2002)	Yes
Adoxophyes orana Fisher von Röeslerstamm = *Adoxophyes fasciata* Walsh [Lepidoptera: Tortricidae]	Apple peel tortricid, smaller tea tortrix, summer fruit tortrix	Feasible	Wide host range and high reproductive rate (Waite & Hwang, 2002).	Significant	Larvae damage fruit by chewing large holes that usually cause fruit rot (CABI, 2002) on a wide range of economic species	Yes
Conopomorpha sinensis Bradley [Lepidoptera: Gracillariidae]	Litchi fruit borer, litchi stem-end borer	Feasible	High reproductive rate with up to eleven generations per year. Suited to tropical and sub-tropical climates.	Significant	Regarded as a destructive pest because larvae bore inside fruit, causing reduction in yield and fruit quality.	Yes
Deudorix epijarbas Moore = *Deudorix epijarbas amatius* Fruhstorfer [Lepidoptera: Lycaenidae]	Cornelian butterfly, fruit borer, grey lychee butterfly	Feasible	Moderate host range (CABI, 2002). Mobile, with a moderate reproductive rate.	Significant	Larvae bore inside fruit causing complete destruction.	Yes

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
PATHOGENS						
FUNGI						
Aspergillus restrictus G. Sm. [Mitosporic fungi: Hyphomycetes]	Fruit rot	Feasible	Cosmopolitan ptahogen (Farr *et al*., 1989)	Not significant	Not considered of economic significance in commercially produced fruit for either domestic or international trade by Australia and its trading partners.	No
Botryodiplodia spp. [Mitosporic fungi: Coelomycetes]	Collar rot	Feasible	*Botryodiplodia* spp. are common in Australia under a range of environmental conditions.	Not significant	Not considered of economic significance in commercially produced fruit for either domestic or international trade by Australia and its trading partners.	No
Capnodium ramosum [Dothidiales: Capnodeaceae]	Sooty mould	Feasible	Associated with the honeydew from sucking insects and can be spread by sucking insects and ants.	Not significant	Appear as superficial black growth on leaves and fruit but do not enter or parasitise host tissue. Although affected fruit may be downgraded for cosmetic reasons, no control is taken specifically against sooty moulds or mildews. Reducing infestations of scale and other insects will control sooty moulds (Coates *et al*., 2003).	No

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Coniothyrium litchii P.K. Chi & Z.D. Jiang	Canker	Feasible	Limited host range	Not significant	Listed as a potential pest of longan by USDA (1999) but not confirmed by China. USDA (1999) does not require management options for this pest.	No
Cylindrocladiella peruviana (Bat., Bez., & Herrera) [Mitosporic fungi: Hyphomycetes]	Cylindrocladiella disease	Feasible	Extensive host range, including many native and exotic species (SBML, 2000). Spores may be dispersed by wind or rain. It is both a high and low temperature species. Similar species are present in Australia (Crous & Wingfield, 1993).	Significant	Affect the roots of a number of crops such as tea, mango, *Prunus* spp. The disease causes poor growth but is generally a minor root rot (Perally, 1974).	Yes
Hexagonia apiaria (Pers.) Fr. [Poriales: Coreiolaceae]		Feasible	Spread by infected plant parts e.g. longan panicles.	Not significant	*Hexagonia* spp. are polypores and are wood-rotting fungi. Unlikely to affect healthy fruiting panicle.	No
Hexagonia heteropora (Montogne) Lmazaki [Poriales: Coreiolaceae]		Feasible	Spread by infected plant parts e.g. longan panicles.	Not significant	*Hexagonia* spp. are polypores and are wood-rotting fungi. Unlikely to affect healthy fruiting panicle.	No

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Meliola eupaniae-majoris [Meliolales: Meliolaceae]	Sooty mildew	Feasible	Other *Meliola* spp. exist in Australia on a wide range of hosts and spread by insects or from leaves and branches to fruit.	Not significant	Appear as superficial black growth on leaves and fruit. Although affected fruit may be downgraded for cosmetic reasons, no control is taken specifically against sooty moulds or mildews. Reducing infestations of scale and other insects will control sooty moulds (Coates *et al*., 2003).	No
Meliola euphoriae [Meliolales: Meliolaceae]	Sooty mildew	Feasible	Other *Meliola* spp. exist in Australia on a wide range of hosts and spread by insects or from leaves and branches to fruit.	Not significant	Appear as superficial black growth on leaves and fruit. Although affected fruit may be downgraded for cosmetic reasons, no control is taken specifically against sooty moulds or mildews. Reducing infestations of scale and other insects will control sooty moulds (Coates *et al*., 2003).	No

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Neocapnodium tanakae (Shirai *et* Hara)	Sooty mould	Feasible	Associated with the honeydew from sucking insects and can be spread by sucking insects and ants.	Not significant	Appear as superficial black growth on leaves and fruit but do not enter or parasitise host tissue. Although affected fruit may be downgraded for cosmetic reasons, no control is taken specifically against sooty moulds or mildews. Reducing infestations of scale and other insects will control sooty moulds (Coates *et al*., 2003).	No
Peronophythora litchii Chen ex Ko *et al*. [Pythiales: Pythiaceae]	Litchi brown blight	Feasible	Affects lychee and longan in a number of countries. Can spread by soil and rain splash during continuously wet periods (CMI, 1989).	Significant	One of the most important diseases of lychee in China (Zhang, 1997). Causes loss of fruit and low commercial value of post-harvest fruit due to off-taste and shortened shelf life (Ou, 2001).	Yes
Phomopsis longanae Chi & Jiang [Diaporthales: Valsaceae]	Fruit blotch, branch canker	Feasible	Although this species has a limited host range and the means of infection is not certain *Phomopsis* spp. have a wide host range and can be spread by spores from infected branches to fruit (Coates *et al*., 2003).	Significant	*Phomopsis* spp. are implicated along with *Diplodia theobromae* and anomorphs of *Botryosphearia* spp. as well as *Colletotrichum* spp. as the most common causal agents of stem-end rot on longan, lychee and rambutan (Coates *et al*., 2003).	Yes

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
Phytophthora palmivora (E.J. Butler) E.J. Butler [Pythiales: Pythiaceae]	Leaf blight, fruit rot Root rot	Feasible	This pathogen has a wide host range and is already established in tropical fruit growing regions of the Northern Territory and Queensland (Ploetz *et al*., 2003)	Significant	*Phytophthora palmivora* causes fruit rot in atemoya, breadfruit, papaya, pond apple, soursop, fig, longan and durian (Ploetz *et al*., 2003). It is an important disease of cacao.	Yes
Pseudoperonospora sp. [Peronosporales: Peronosporaceae]		Feasible	This genus is already present in Australia on a range of hosts.	Not significant	There is a lack of information on the *Pseudoperonospora* sp. on longan in China or of any damage caused thus indicating a lack of economic significance. The pathogen was not considered further by the USDA (1999) where the reference was obtained.	No
Yeast (unidentified)	Yeast	Feasible	Yeasts are universal and it is feasible that conducive conditions exist in Australia.	Not significant	Yeasts have been isolated from post-harvest decay of longan and lychee fruit but a causal relationship has not been determined (Fitzell & Coates, 1995).	No

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for economic consequences		Consider pest further?
		Feasible/ Not feasible	Comments	Significant/ Not significant	Comments	
DISEASE OF UNKNOWN AETIOLOGY						
LWBD Mycoplasma-like/Filamentous virus? Organism	Longan witches' broom disease	Feasible	The disease is mostly transmitted by budwood and vectors in China (Chen *et al.,* 2001). Sucking insects and mite vectors could be potential vectors in Australia. Longan witches' broom may transmitted to lychee through vectors (Chen *et al*., 1996)	Significant	Witches' broom has been described as the only significant disease affecting longan in Asia (Menzel *et al*., 1989) causing annual losses of 10-20% or up to 50% (Chen *et al*., 1990). Although not reported in Thailand and lack of evidence that disease exists on lychee in China (AQSIQ, 2003a, b; DOA, pers. comm., 2003) affects on lychee trees would be equally damaging.	Yes

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APPENDIX 3 – PEST DATA SHEETS

ARTHROPODS

Scarab beetles

***Maladera castanea* (Arrow, 1913) [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: *Aserica castanea* Arrow; *Autoserica castanea* (Arrow).

Common name(s): Asiatic garden beetle.

Host(s): Adults of *Maladera castanea* feed on over 100 species of plants (Shetlar and Niemczyk, 1999). Hosts include: *Arachis hypogaea* (groundnut) (Meyer-Rochow and Gokan, 1987); *Aster* sp. (Anon., 2003; Shetlar and Niemczyk, 1999); *Berberis vulgaris* (common barberry) (Anon., 2003); *Chrysanthemum* sp. (Anon., 2003), *Dahlia* sp. (Anon., 2003; Shetlar and Niemczyk, 1999); *Dimocarpus longan* (longan) (AQSIQ, 2003; Tan *et al*., 1998); *Fragaria* sp. (strawberry) (Anon., 2003); *Geranium* sp. (Anon., 2003); *Ipomoea batatas* (sweet potato) (Meyer-Rochow and Gokan, 1987); *Litchi chinensis* (lychee) (CIQ, 2000; Tan *et al*., 1998); *Physalis viscosa* (grape ground-cherry) (Anon., 2003); *Rhododendron* sp. (azalea, rhododendron) (Anon., 2003); *Rosa* sp. (rose) (Shetlar and Niemczyk, 1999); conifers (Anon., 2003).

Plant part(s) affected: Larvae occasionally attack turf in the USA but seem to prefer a variety of roots from weeds, flowers and vegetables (Shetlar and Niemczyk, 1999). Larvae attack the roots of grass, weeds, flowers and vegetables (Shetlar and Niemczyk, 1999). Adults eat the leaves of hosts (Shetlar and Niemczyk, 1999); they also affect new leaves and stems of longan and lychee plants (CIQ, 2000; Tan *et al*., 1998). This species is also known to feed on the pericarp of longan and lychee fruits (AQSIQ, 2003).

Distribution: China (Tan *et al*., 1998); Japan (Brown *et al*., 1983); United States (New England to Ohio and down into South Carolina) (Shetlar and Niemczyk, 1999).

Biology: Eggs are laid in clusters of 3-15 and loosely held together by a gelatinous material just below the soil surface beneath host plants (Shetlar and Niemczyk, 1999). Individual eggs are oval and about 1 mm long. After absorbing water, the eggs become spherical. Newly hatched larvae are about 1.4 mm long and have light brown head capsules. Fully-grown larvae are 15-18 mm long when stretched out. The grubs are commonly identified by the enlarged, light coloured appendages just behind the mandibles, or mouthparts, which appear to be in constant motion. The pupae rest in the last larval skin

and are 8-10 mm long. At first they are white and gradually turn tan. Adults are 7-10 mm long and are broadly wedge-shaped. They are chestnut brown in colour and often have a slight iridescent, velvety sheen. The abdomen protrudes slightly from under the wing covers and the undersurface of the thorax has an irregular covering of short yellow hairs. The hind legs are distinctly larger and broader than the others.

In the USA, adult beetles may be active from late June to the end of October, but most of the adults are found from mid-July to mid-August. Adults emerge at night to feed and fly actively on warmer nights. They generally strip foliage off of plants leaving a ragged appearance (Shetlar and Niemczyk, 1999). They do not skeletonise leaves like Japanese beetles tend to. Flowers often have the petals eaten off (Shetlar and Niemczyk, 1999). The adults are strongly attracted to lights. During the day, beetles hide in the soil around favoured food plants.

After feeding for several nights, the females begin laying eggs in small clusters of 60 about 5 cm beneath the soil surface (Shetlar and Niemczyk, 1999). Eggs are laid over several weeks and normally hatch in 10 days during summer temperatures (Shetlar and Niemczyk, 1999). Young larvae dig into the soil surface where they feed on roots and decomposing organic material. Most first instar larvae are found in August and early September. Second instars are found in September and many do not reach third instar until the following spring. About half the population overwinter as second instars and the remainder as partially developed third instars. As cool October temperatures arrive, the larvae burrow down 15-30 cm to pass the winter. The larvae return to the soil surface in the spring and all seem to mature by mid-June at which time they pupate 3-6 cm in the soil in compacted earthen cells. The pupal stage is relatively short, lasting 8-15 days. The adult remains in the old pupal skin, changing from white to the mature chestnut brown, for a few days before digging to the surface. There is one generation per year (Shetlar and Niemczyk, 1999).

Control: Eggs of *Maladera castanea* require moisture for development so restricting irrigation at the right time may significantly reduce survival (Shetlar and Niemczyk, 1999). Commercially available preparations containing the nematode *Heterorhabditis* spp. seem to be effective in controlling *M. castanea* in lawns in the USA. Nematodes can be applied when white grubs are in the second instar. Irrigation before and after nematode application with a minimum of 10 mm of water increases efficacy (Shetlar and Niemczyk, 1999).

Trichlorfon provides good chemical control of this species (Anon., 2003). Azadirachtin, carbaryl, or chlorpyrifos, which are among the compounds registered for control of this pest in Connecticut, can be applied to foliage when adults are present. Otherwise, treating with imidacloprid as a systemic may kill adults feeding on the foliage (Anon., 2003).

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***Oxycetonia jucunda* (Faldermann, 1835) [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: *Cetonia jucunda* Faldermann.

Common name(s): Citrus flower chafer; smaller green flower chafer.

Host(s): *Citrus reticulata* var. *unshiu* (Unshu orange) (APHIS, 2002); *Citrus* sp. (Nishino *et al*., 1970; Ogihara *et al*., 1989); *Dimocarpus longan* (longan) (Tan *et al*., 1998); *Litchi chinensis* (lychee) (Tan *et al*., 1998); *Malus domestica* (apple) (Majzlan and Rychilik, 1991); *Pyrus* × *bretschneideri* (Ya pear) (Cave and Lightfield, 1997).

Plant part(s) affected: *Oxycetonia jucunda* feeds on the flowers and fruits of longan and lychee (AQSIQ, 2003; Tan *et al*., 1998). The leaves and roots of Unshu orange are attacked (APHIS, 2002) and plant parts, apart from the fruit of Ya pear, are fed on (Cave and Lightfield, 1997).

Distribution: China (CIQ, 2000; Majzlan and Rychilik, 1991; Tan *et al*., 1998); Japan

(Yokomizo and Nagano, 1987); Korea (Anon, 2002; Kim *et al*., 1990).

Biology: Adults are 11-16 mm long and oval in shape from above. They are dark green to black in colour with yellow/white spots on their elytra and many short setae covers their body. These setae are concentrated laterally. One life cycle takes between 1-2 years and the adult life span is 4-10 months (Anon., 2000). Larvae eat vegetation that is rotting on the ground beneath host plants. Adults generally feed on the flowers and fruits of their hosts (Anon., 2000).

Control: None known.

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***Popillia mutans* Newman [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: *Popillia indigonacea* Motschulsky; *Popillia indigonacea* Stebnicka.

Common name(s): None.

Host(s): *Dimocarpus longan* (longan) (AQSIQ, 2003a, b; Tan *et al*., 1998); *Diospyros kaki* var. Fuyu (sweet persimmon) (Lee *et al*., 2002); *Litchi chinensis* (lychee) (AQSIQ, 2003a, b; Tan *et al*., 1998).

Plant part(s) affected: Adults feed on flowers and leaves of longan and lychee plants and occasionally, they damage young fruit (AQSIQ, 2003a, b). Tan *et al*. (1998) recorded that *P. mutans* feeds on longan and lychee fruits.

Distribution: China (Anon., 2003; CIQ, 2000; Tan *et al*., 1998), French Indochina (Anon., 2003), Korea (Kim, 1995). Not in Australia (Houston, 1992).

Biology: Detailed biological information for *Popillia mutans* could not be found. Please refer to the next datasheet on *Popillia quadriguttata*.

Control: None.

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***Popillia quadriguttata* (Fabricius, 1787) [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: *Trichius quardriguttata* Fabricius; *Popillia chinensis* Frivaldszky; *Popillia ruficollis* Kraatz; *Popillia uchidai* Niijima and Kinoshita.

Common name(s): White grub.

Host(s): *Acalypha australis* (Australian acalypha) (Lee *et al*., 2002); *Amelanchier asiatica* (Korean juneberry) (Lee *et al*., 2002); *Amorpha fruticosa* (bastard indigo bush) (Chung, 1983); *Ampelopsis brevipedunculata* (porcelain berry) (Sang, 1979); *Arachis hypogaea* (peanut) (Sang, 1979); *Artemisia princeps* var. *orientalis* (Lee *et al*., 2002); *Berberis poiretii* (Sang, 1979); *Camellia sinensis* var. *sinensis* (Chinese tea) (Lee *et al*., 2002); *Castanea mollissima* (Chinese chestnut) (Sang, 1979); *Chaenomeles speciosa* (Chinese flowering quince) (Lee *et al*., 2002); *Chionanthus retusus* (Chinese fringe tree) (Lee *et al*., 2002); *Chloris virgata* (feather finger grass) (Lee *et al*., 2002); *Cleyera japonica* (sakaki) (Lee *et al*., 2002); *Corylus heterophylla* (Siberian hazelnut) (Sang, 1979); *Crataegus pinnatifida* (Chinese hawthorn) (Sang, 1979); *Dimocarpus longan* (longan) (AQSIQ, 2003a, b; Tan *et al*., 1998); *Dioscorea nipponica* (Sang, 1979); *Dioscorea septemloba* (Lee *et al*., 2002); *Diospyros kaki* (Japanese persimmon) (Lee *et al*., 2002); *Diospyros lotus* (lotus persimmon) (Lee *et al*., 2002); *Euonymus alatus* (winged spindle tree) (Lee *et al*., 2002); *Glycine max* (soybean) (Sang, 1979); *Glycine max* (soybean) (Chung, 1983); *Helicteres angustifolia* (Chung, 1983); *Hemiptelea davidii* (Sang, 1979); *Hibiscus syriacus* (rose of Sharon) (Lee *et al*., 2002); *Hypericum ascyron* (great St John's wort) (Sang, 1979); *Ilex crenata* (box-leaf holly, Japanese holly) (Lee *et al*., 2002); *Ilex rotunda*

(kurogane holly) (Lee *et al*., 2002); *Ipomoea batatas* (sweet potato) (Sang, 1979); *Lespedeza cyrtobotrya* (leafy lespedeza) (Lee *et al*., 2002); *Ligustrum obtusifolium* (border privet) (Lee *et al*., 2002); *Lindera erythrocarpa* (spice bush) (Lee *et al*., 2002); *Liriodendron tulipifera* (tulip tree) (Lee *et al*., 2002); *Litchi chinensis* (lychee) (AQSIQ, 2003a, b; Tan *et al*., 1998); *Lysimachia barystachys* (Manchurian yellow loosestrife) (Lee *et al*., 2002); *Malus pumila* (paradise apple) (Sang, 1979); *Malus pumila* var. *dulcissima* (Chung, 1983); *Menispermum dauricum* (Sang, 1979); *Oenothera odorata* (fragrant evening primrose) (Sang, 1979); *Persicaria senticosa* (Lee *et al*., 2002); *Platanus orientalis* (Oriental plane) (Lee *et al*., 2002); *Polygonum lapathifolium* (pale smartweed, willow weed) (Sang, 1979); *Populus simonii* (Chinese poplar) (Sang, 1979); *Prunus davidiana* (Chinese wild peach) (Lee *et al*., 2002); *Prunus mume* (Japanese apricot) (Lee *et al*., 2002); *Prunus persica* (peach) (Sang, 1979); *Prunus salicina* (Japanese plum) (Lee *et al*., 2002); *Prunus sargentii* (Sargent cherry) (Sang, 1979); *Pteridium aquilinum* (bracken fern) (Sang, 1979); *Punica granatum* (pomegranate) (Lee *et al*., 2002); *Pyracantha angustifolia* (orange firethorn) (Lee *et al*., 2002); *Pyrus ussuriensis* var. *mecrostipes* (Lee *et al*., 2002); *Pyrus* spp. (pear) (Chung, 1983); *Quercus aliena* (Oriental white oak) (Lee *et al*., 2002); *Quercus mongolica* (Mongolian oak) (Sang, 1979); *Quercus serrata* (ko-nara) (Lee *et al*., 2002); *Rhapontica uniflora* (Lee *et al*., 2002); *Robinia pseudoacacia* (black locust) (Sang, 1979); *Rubus crataegifolius* (raspberry) (Sang, 1979); *Rubus parvifolius* (Japanese raspberry, trailing raspberry) (Choo *et al*., 2000); *Salix koreensis* (Chung, 1983); *Schizandra chinensis* (schizandra berry) (Sang, 1979); *Solanum lyratum* (Lee *et al*., 2002); *Solanum tuberosum* (potato) (Sang, 1979); *Sorbus lommixta* (Lee *et al*., 2002); *Sorghum vulgare* (sorghum) (Sang, 1979); *Styphnolobium japonicum* (Japanese pagoda tree) (Lee *et al*., 2002); *Styrax japonicus* (Japanese snowbell) (Lee *et al*., 2002); *Symplocos paniculata* (sapphire berry) (Lee *et al*., 2002); *Tilia mandshurica* (Manchurian linden) (Lee *et al*., 2002); *Wisteria floribunda* (Japanese wisteria) (Lee *et al*., 2002); *Ulmus parvifolia* (Chinese elm) (Lee *et al*., 2002); *Ulmus pumila* (Siberian elm) (Chung, 1983); *Viburnum odoratissimum* var. *awabuki* (Awabuki sweet viburnum) (Lee *et al*., 2002); *Viburnum sargentii* (Sargent viburnum) (Lee *et al*., 2002); *Vitis coignetiae* (crimson gloryvine) (Lee *et al*., 2002); *Zanthoxylum piperitum* (Japanese pepper) (Sang, 1979); *Zanthoxylum* spp. (Chung, 1983); *Zea mays* (corn, maize) (Chung, 1983); *Ziziphus jujuba* var. *inermis* (Lee *et al*., 2002).

Plant part(s) affected: Flower; fruit, leaf (AQSIQ, 2003a, b; Sang, 1979). Adults feed on flowers and leaves of longan and lychee plants and occasionally, they damage young longan and lychee fruit (AQSIQ, 2003a, b). Tan *et al*. (1998) recorded that *P. quadriguttata* feeds on longan and lychee fruits.

Distribution: China (CIQ, 2000; Tan *et al*., 1998); Korea (Ku *et al*., 1999).

Biology: Detailed biological information for *Popillia quadriguttata* could not be found. However, information regarding *Popillia japonica*, a species from the same genus that has

been misidentified as *P. quadriguttata* (Ku *et al*., 1999) is outlined below.

The eggs of *P. japonica* are elliptical, white and about 1.5 mm long. Larvae are C-shaped, creamy white grubs with a yellowish-brown head. They are less than 25 mm long at maturity and are laid in the fibrous root zone of host plants (Wallace, 2001). The pupae are found 5-8 cm beneath the soil surface. Pupae are about the same size as adults and somewhat resemble the adult except that the legs, antennae and wings are closely folded to the body. The pupal body, which is at first a pale cream colour, gradually becomes tan and finally the metallic green of the adult. The V-shaped arrangement of the last two rows of spines on the last body segment distinguishes this grub from all others. Adults have an oval outline from above and are about 10 mm long and 6 mm wide. The abdomen, thorax and head are metallic green with metallic copper-brown wing coverings and contrasting white tufts of hair along the sides and rear of the abdomen. Adults are active on warm sunny days in southern Ontario, USA (Wallace, 2001).

There is only one generation of *P. japonica* per year (Wallace, 2001). In North America and Canada, adults appear in summer and are very active for about 6 to 8 weeks. Their normal life span is from 30 to 45 days (Wallace, 2001). Beetles begin flying when the temperature is about 21ºC. Their flight is aimless except in response to chemical stimuli of food plants or sex pheromone. Most flights are short distances, but the beetle is capable of flying up to 8 km with the wind. Beetles prefer to feed on plants exposed to the direct rays of the sun, beginning at the top, regardless of height, and working downward. They feed on the upper surface of the foliage of most plants, chewing the tissue between the veins, leaving a lace-like skeleton (Wallace, 2001). As leaves on trees become less attractive, the beetles leave the trees and become more abundant on flowers or in field crops such as, corn and clover. The female deposits up to 60 eggs about 8 cm deep in soil of lawns and other grassy areas (Wallace, 2001). Eggs hatch in about two weeks and the small larvae begin to feed on grass roots. Feeding continues until the approach of cold weather. They spend the winter from 5-31 cm below the surface and resume feeding in the spring. There are three larval stages or instars. Most pass the winter in the third instar. When full grown, they pupate and after a resting period of about two weeks emerge as adult beetles in late June or early July (Wallace, 2001).

Control: Pathogens of *P. quadriguttata* include *Bacillus popilliae* attacking larvae in China (Yang and Liu, 1981), and the nematode *Macracanthorhynchus hirudinaceus* which attacks adults in China (Ren *et al*., 1994).

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***Protaetia brevitarsis* (Lewis, 1879) [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: *Ceotocia brevitarsis* Lewis; *Neotocia*

brevitarsis (Lewis); *Liocola brevitarsis* (Lewis); *Potosia brevitarsis* (Lewis); *Protaetia* (*Calopotosia*) *brevitarsis* (Lewis). *Potosia* is a synonym of the genus *Protaetia*.

Common name(s): Flower beetle; white-spotted flower chafer.

Host(s): *Litchi chinensis* (lychee) (He, 2001).

Plant part(s) affected: Flower (Malec, 2003); fruit (AQSIQ, 2003; He, 2001).

Distribution: The genus *Protaetia* is widely distributed throughout Europe (Malec, 2003). China (He, 2001); Korea, Republic of (Park *et al*., 1994).

Biology: There is limited published information on the biology of *Protaetia brevitarsis*.

Beetles in the family Scarabaeidae, to which *P. brevitarsis* belongs, are usually medium to large in size, occasionally with bright colour. Adult beetles usually feed on leaves and flowers (Anon., 2003). Their larvae are always live in concealed habitats, feeding on roots, dung or decaying plants materials (Anon., 2003). They are sluggish, cylindrical, C-shaped, with well-developed head and legs.

Protaetia brevitarsis was collected in South Korea and under specific laboratory conditions they require 120-150 days for a generation (Park *et al*., 1994). Larvae hatch from eggs after 10 days, the larvae pupate after another 55 days and the pupae metamorphose into adults after 30 days. The adults lived for approximately 45 days (Park *et al*., 1994). Females lay an average of 68 eggs in the laboratory conditions (Park *et al*., 1994).

Control: None known.

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***Protaetia fusca* Herbst [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: *Cetonia mandarinea; Protaetia mandarina* Lichtenstein.

Common name(s): Mango flower beetle; mottled flower scarab.

Host(s): *Ananas comosus* (pineapple) (CAB International, 2003); *Cajanus cajan* (pigeon pea) (CAB International, 2003); *Citrus* spp. (Simpson, 1990); *Dimocarpus longan* (longan) (Tan *et al*., 1998); *Ficus* sp. (fig) (Simpson, 1990); *Litchi chinensis* (lychee) (Tan *et al*., 1998); *Mangifera indica* (mango) (CAB International, 2003); *Persea americana* (avocado) (Simpson, 1990); *Prunus persica* (peach) (Simpson, 1990); *Rosa* sp. (rose) (Simpson, 1990); *Saccharum officinarum* (sugarcane) (CAB International, 2003); *Zea mays* (maize) (CAB International, 2003).

Protaetia fusca has also been recorded feeding on flowering weeds occurring in citrus, avocado, fig, peach and rose crops (Simpson, 1990).

Plant part(s) affected: Flowers (Malec, 2003); inflorescences, new growth (Simpson, 1990); fruit (AQSIQ, 2003).

Distribution: Australia (Lea, 1914); Indonesia (Miksič, 1966); India (Miksič, 1966); Mauritius (Miksič, 1966); Sri Lanka (Miksič, 1966); Burma (Miksič, 1966); Philippines (Miksič, 1966), Japan (Kohno, 2000), Papua New Guinea (Husband and Kurosa, 1994); USA (Hawaii) (Miksič, 1966).

In Australia, *P. fusca* has been recorded along coastal Queensland from Brisbane to Cairns (Lea, 1914) and also from Darwin in the Northern Territory (Simpson, 1990). AICN (2003) reports this species from New South Wales, Queensland and the Northern Territory. *Protaetia fusca* is not present in Western Australia (DAWA, 2003).

Biology: Beetles in the family Scarabaeidae, to which *P. fusca* belongs, are usually medium to large in size, occasionally with bright colour. Adult beetles usually feed on leaves and flowers (Anon., 2003). Their larvae are always live in concealed habitats, feeding on roots, dung or decaying plants materials (Anon., 2003). They are sluggish,

cylindrical, C-shaped, with well-developed head and legs.

Protaetia fusca adults are approximately 11mm long with a small number of white dots on their elytra (black wing covers) (Chew, 2003). Eggs are whitish, ovoid and approximately 2.2mm long. There are three larval instars that are 4-11mm, 16-20mm and 20-32mm long respectively. Pupation occurs in a chamber that is 17mm long and 12mm wide. Pupae are without strong mouthparts and their legs and wings are free from their body (Simpson, 1990).

In avocado orchards in Queensland, *Protaetia fusca* seems to breed continuously. Eggs are laid individually as a female crawls through the mulch on the ground. Under controlled conditions, a caged pair laid 147 eggs over a 27-week period and half of these were laid in the first 8 weeks. Females die shortly after their final egg is laid and males live for a similar period of time. Larvae develop in the mulch, but they do not burrow into the soil. The pupal chamber is constructed within the mulch. At 25.5ºC the development of eggs, 1st, 2nd and 3rd instar larvae and pupae took 9.0 days, 4.1, 8.8, 26.6 and 4.0 weeks, respectively. The total time between egg and adult is 44 ± 0.3 weeks (Simpson, 1990).

Protaetia fusca are found during early summer in Brisbane, Queensland (Chew, 2003). Adult beetles feed on nectar and sap (Simpson, 1990).

Control: Natural enemies of adult *Protaetia fusca* in Australia include the bird *Dacelo novaeguineae* (Hermann) (kookaburra) and the fungus *Aspergillus flavus* Link. *Threskiornis spinicollis* (Jameson), the straw-necked ibis, is an effective larval predator and adult wasps of *Scolia verticalis* F. have been bred from *P. fusca* larvae (Simpson, 1990).

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***Protaetia nitididorsis* (Fairmaire) [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: *Cetonia esquiroli* Pouillaude; *Liocola nitididorsis* Fairmaire; *Liocola speculifera* Schwartz. *Potosia* is a synonym of the genus *Protaetia*.

Common name(s): Chafer; flower beetle; metallic beetle.

Host(s): *Dimocarpus longan* (longan), *Litchi chinensis* (lychee) (CIQ, 2000; Tan *et al*., 1998).

Plant part(s) affected: Fruit (Tan *et al*., 1998).

Distribution: The genus *Protaetia* is widely distributed throughout Europe (Malec, 2003). *Protaetia nitididorsis* is recorded in China (CIQ, 2000; Tan *et al*., 1998).

Biology: Detailed biological information specifically for *Protaetia nitididorsis* could not be found.

Beetles in the family Scarabaeidae, to which *P. nitididorsis* belongs, are usually medium to

large in size, occasionally with bright colour. Adult beetles usually feed on leaves and flowers (Anon., 2003). Their larvae are always live in concealed habitats, feeding on roots, dung or decaying plants materials (Anon., 2003). They are sluggish, cylindrical, C-shaped, with a well-developed head and legs.

Adult *Liocola lugubris* are 19-25 mm long and adult *Potosia aeruginosa* are 22-28 mm long (Malec, 2003). Both of these species occur in the Czech Republic where the larvae live in old oak trees (*Quercus* sp.), and sometimes in osiers (*Salix* sp.), especially *L. lugubris*. In captivity, the life cycle is 6-8 months. Adults live to one year (Malec, 2003).

Protaetia brevitarsis was collected in South Korea and under specific laboratory conditions they require 120-150 days for a generation (Park *et al*., 1994). Larvae hatch from eggs after 10 days, the larvae pupate after another 55 days and the pupae metamorphose into adults after 30 days. The adults live for approximately 45 days (Park *et al*., 1994). Females lay an average of 68 eggs in the laboratory conditions (Park *et al*., 1994).

Control: None known.

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Anon. (2003). *Scarab Beetles, Chafers and Dung Beetles, Family Scarabaeidae*. http://www.geocities.com/brisbane_beetles/SCARABAEIDEA.htm

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***Xylotrupes mniszechi* Thomson 1859 [Coleoptera: Scarabaeidae]**

Synonyms and changes in combination: Included previously in *Xylotropes gideon* (Linnaeus) taxon. ?*X. mniszechii* Thomson 1859; *X. socrates* Schaufuss 1863; *X. tonkinensis* Minck 1920; *X. gideon mniszechi* Endrödi 1951; *X. gideon tonkinensis* Endrödi 1951*; ?X. gideon kaszabi* Endrödi 1951*; X.gideon socrates* Endrödi 1951 (Rowland,

2003*)*.

Rowland (2003) recently conducted a phylogenetic analysis of the genus *Xylotrupes*, which suggested that it is monophyletic and composed of six lineages treated as distinct species. The *Xylotrupes gideon* taxon is considered to be made up of itself and five additional species based on morphological differences and geographical isolation of the specimens analysed. The five species are: *X. florensis* Lansberge 1879; *X. meridionalis* Prell 1914 *X. ulysses* (Guérin-Méneville) 1830 *X. pubescens* Waterhouse 1841 and *X. mniszechi* Thomson 1859.

Common name(s): Rhinoceros beetle; elephant beetle.

Host(s): Attributed previously to taxon *X. gideon* - *Ananas comosus* (pineapple) (Waite and Elder, 2000); *Bambusa vulgaris* (bamboo) (CAB International, 2002); *Cocos nucifera* (coconut) (CAB International, 2002); *Cinnamomum* sp. (cinnamon) (CAB International, 2002); *Dimocarpus longan* (longan) (Waite and Elder, 2000); *Elaeis guineensis* (African oil palm) (CAB International, 2002); *Hevea brasiliensis* (rubbertree) (CAB International, 2002); *Litchi chinensis* (lychee) (Waite and Elder, 2000); *Musa* sp. (banana, plantain) (CAB International, 2002); *Saccharum officinarum* (sugarcane) (CAB International, 2002); *Solanum tuberosum* (potato) (CAB International, 2002).

Plant part(s) affected: Bark, fruit, panicle (Waite and Elder, 2000).

Distribution: Attributed previously to taxon *X. gideon*: Australia (New South Wales, Northern Territory, Queensland) (AICN, 2002); Bangladesh, Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippines, Solomon Islands, Sri Lanka, Thailand, Vanuatu, Vietnam (CAB International, 2002).

Xylotrupes florensis (Lesser Sunda Island from Flores Island to the Tanimbar Islands, Indonesia;
X. meridionalis (Sri Lanka and southern India);
X. ulysses (Sulawesi and Sangi Island, east through Molucca Islands, Australia, Papua New Guinea and Melanesia to Vanuatu;
X. pubescens (Philippines, southern Sulawesi and Sumatra); and
X. mniszechi (Himalaya region, south-east Asia, China and Lanshu Island, Taiwan) (Rowland, 2003).

Biology: [Information provided relates to the *X. gideon* taxon from Australian sources]. Adult beetles are black and about 30-40 mm in length, with the male being the larger (Waite and Elder, 2000). The male has two large projections (‘horns’) on the head and another on the prothorax. By appropriate movements they can, to some extent, move the

ends together like tweezers. Only males have these horns. Females are quite plain and seen less often.

The female lays about 50 white eggs in decaying/rotting organic matter (Chew, 2003). They hatch into small white C-shaped larvae (called white grubs) with a dark-brown head and 6 small legs. The larvae develop in the soil or mulch where they feed on plant roots and humus (Waite and Elder, 2000), and decaying vegetable matter (Chew, 2003). The egg stage takes 3 weeks, the larval stage 29 weeks and the pupal stage 5 weeks at about 26°C (Waite and Elder, 2000). The heavily-sclerotised and sexually dimorphic adults emerge in spring.

The beetles are attracted to the fruit as they ripen, especially those that have split or been damaged by parrots and fruit bats (Menzel, 2002). Adults also feed on the bark of poinsettia and other trees (Waite and Elder, 2000). They then start attacking sound fruit and can cause significant economic losses in the week or so leading up to harvest (Menzel, 2002). Economic losses will occur if more than 30 beetles are found (Waite and Elder, 2000). 'Wai Chee', 'Bengal' and other later maturing lychee varieties are particularly affected (Waite and Elder, 2000); Whole fruit and some times whole panicles of fruit are damaged by their chewing activity (Waite and Elder, 2000). Subsequent spoilage of undamaged fruit occurs because of staining caused by dripping juice from damaged fruit. The larvae may be a problem in many species of container grown plants where the potting mixture has a high proportion of organic matter (Waite and Elder, 2000). There is no evidence to indicate that the horn morphology differences distinguishing the species present in Thailand and China (now given as X. *mniszechii* Thomson 1859) differs in its pest status from the taxon *X. gideon* and/or the species present in Australia (now given as *X. ulysses* (Guérin-Méneville) 1830.

Control: Cultural control methods for *X. gideon* in Australia include excluding beetles with netting of a suitable mesh size, for example 20 mm mesh or less (Waite and Elder, 2000). Biological control methods involve manual removal of the beetles from trees (Waite and Elder, 2000). However, this method is only really effective on small trees and difficult on large ones. Labour is relatively expensive in Australia, so this operation adds significantly to growing costs (Menzel, 2002). There is no chemical control for this pest (Waite and Elder, 2000).

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Fruit flies

***Bactrocera cucurbitae* (Coquillett, 1899) [Diptera: Tephritidae]**

Synonyms and changes in combination: *Dacus cucurbitae* Coquillett; *Chaetodacus cucurbitae* (Coquillett); *Dacus aureus* Tseng and Chu; *Dacus yuiliensis* Tseng and Chu; *Strumeta cucurbitae* (Coquillett); *Zeugodacus cucurbitae* (Coquillett).

Common name(s): Melon fruit fly; melon fly.

Host(s): *Bactrocera cucurbitae* is a very serious pest of cucurbit crops. According to Weems (1964) it has been recorded from over 125 plants, including members of families other than Cucurbitaceae. However, many of those records were based on casual observation of adults resting on plants or caught in traps set in non-host trees (CABI, 2002).

B. cucurbitae has been collected in *Litchi chinensis* (lychee) orchards in central Taiwan (Fang and Chang, 1984) and southern Taiwan (Wen, 1985). This species has not been recorded on longan and lychees in China (AQSIQ, 2003a; CIQ, 2000) or Thailand (DOA, 2000a, b; 2003a, b). CABI (2002) records that *B. cucurbitae* is present in Taiwan, China and Thailand.

Hosts include: Cucurbitaceae (cucurbit), *Abelmoschus moschatus* (musk okra), *Artocarpus heterophyllus* (jackfruit), *Benincasa hispida* (wax gourd), *Carica papaya* (pawpaw), *Citrullus colocynthis* (bitter apple), *Citrullus lanatus* (watermelon), *Citrus hystrix* (Mauritius papeda), *Citrus maxima* (pummelo), *Citrus sinensis* (navel orange), *Cucumis auguria* (gherkin), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita maxima* (giant pumpkin), *Cucurbita moschata* (pumpkin), *Cucurbita pepo* (ornamental gourd), *Cydonia oblonga* (quince), *Cyphomandra betacea* (tamarillo), *Ficus carica* (fig),

Lagenaria siceraria (trumpet gourd), *Luffa acutangula* (angled luffa), *Luffa cylindrica* (loofah), *Lycopersicon esculentum* (tomato), *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Momordica balsamina* (balsam apple), *Momordica charantia* (bitter gourd), *Passiflora edulis* (passionfruit), *Persea americana* (avocado), *Phaseolus vulgaris* (bean), *Prunus persica* (peach), *Psidium guajava* (guava), *Sechium edule* (chayote); *Sesbania grandiflora* (gallito), *Syzygium samarangense* (wax apple), *Trichosanthes cucumerina* var. *anguinea* (snake gourd), *Trichosanthes cucumerina* (snake gourd), *Vigna unguiculata* (cowpea), *Ziziphus jujuba* (jujube) (Allwood, *et al*., 1999; Tsuruta *et al*., 1997).

Plant part(s) affected: Fruit, inflorescence (CABI, 2002; Ronald and Jayma, 1991).

Distribution: Afghanistan, Africa, Australia (Queensland), Bangladesh, Brunei Darussalam, Cambodia, Cameroon, China (Guangdong, Guangxi, Hainan, Hong Kong, Jiangsu, Yunnan), Christmas Island, Egypt, Gambia, Guam, India (Andaman and Nicobar Islands, Andhra Pradesh, Assam, Bihar, Delhi, Haryana, Himachal Pradesh, Indian Punjab, Jammu and Kashmir, Karnataka, Kerala, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal), Indonesia (Irian Jaya, Java, Kalimantan, Nusa Tenggara, Sulawesi, Sumatra), Iran, Japan (Ryukyu Archipelago), Kenya, Kiribati, Laos, Malaysia (Peninsular Malaysia, Sabah, Sarawak), Mauritius, Myanmar, Nauru, Nepal, Northern Mariana Islands, Oman, Pakistan, Papua New Guinea (Bougainville), Philippines, Réunion, Saudi Arabia, Singapore, Solomon Islands, Sri Lanka, Taiwan, Tanzania, Thailand, United Arab Emirates, USA (Hawaii), Vietnam (CABI, 2002).

Biology: The eggs of *Bactrocera cucurbitae* are probably similar to those of *Bactrocera oleae* which were described in detail by Margaritis (1985). They are 0.8 mm long, 0.2 mm wide and white to yellow-white in colour. Third instar larvae of *B. cucurbitae* are large, 9-11 mm long and 1-2 mm wide. The puparium is barrel-shaped, white to yellow-brown in colour and usually about 60-80% as long as the larvae (CABI, 2002). The adult body is predominantly orange to brown in colour and 6-8 mm in length. Dorsally, the thorax has three short, parallel white to yellow stripes on the central plate. The scutellum, or last thoracic plate, is uniformly pale brown. The wing length is 4.2-7.1 mm and each wing has a distinct dark stripe running across it. All the legs are pale basally and turn red/brown apically. The abdomen is predominantly orange/brown in colour, ovate or parallel sided and, in lateral view, it is arched and rather ridged. Dorsally, the abdomen has a dark T-pattern over the last three segments (Carrol *et al*., 2002). Generally, adults live for 10-12 months (Ronald and Jayma, 1991).

B. cucurbitae is easily separated from most other *Bactrocera* spp. by the combination of the general orange/brown coloured body, the white to yellow stripes on the thorax and the dark stripe across each wing (CABI, 2002).

Females lay up to 40 eggs below the skin of the host fruit. Following oviposition there may be some necrosis around the puncture mark (‘sting’). This can be followed by

decomposition of the fruit. Eggs hatch within 1-2 days and the larvae feed for another 4-17 days. Pupation is in the soil under the host plant for 7-13 days but may be delayed for several weeks under cool conditions. Adults occur throughout the year and begin mating (at dusk) after about 10-12 days, and may live 5-15 months depending on temperature (longer in cool conditions) (Christenson and Foote, 1960; Clausen, 1978; Waterhouse, 1993a).

Adult flight and the transport of infected fruit are the major means of movement and dispersal of *B. cucurbitae* to previously uninfected areas. Many *Bactrocera* spp. can fly 50-100 km (Fletcher, 1989). Plant parts liable to carry the pest in trade/transport include fruits that can house eggs and larvae internally; growing medium accompanying the plants in which pupae can reside and flowers and/or inflorescences (CABI, 2002). All stages of *B. cucurbitae* are visible to the naked eye (CABI, 2002). The major risk is from the import of fruit containing larvae, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail (Baker and Cowley, 1991).

Control: One of the most effective control techniques against fruit flies in general is to wrap fruit, either in newspaper or a paper/plastic bag. This is a simple physical barrier to oviposition but it has to be applied well before the fruit is attacked (CABI, 2002). Some benefit from biological control has been claimed in Hawaii and the Ryukyu Islands, Japan (Clausen, 1978). Although cover sprays of entire crops are sometimes used to control fruit flies, the use of bait sprays is both more economical and more environmentally acceptable (CABI, 2002). There has been some recent work on the efficacy of enteropathogenic fungi to *B. cucurbitae* larvae (Purnima and Saxena, 1998, 1999) but it is not clear how this could be applied without causing fruit spoilage. Tests have also shown that neem (*Azadirachta indica*) seed kernel extracts can be used as an oviposition deterrent (Shivendra and Singh, 1998).

Bactrocera spp. can be attacked as larvae either by parasitoids or by vertebrates eating fruit (either on the tree or as fallen fruit). Mortality due to vertebrate fruit consumption can be very high as can puparial mortality in the soil, either due to predation or environmental mortality (see White and Elson-Harris, 1994). Parasitoids appear to have little effect on the populations of most fruit flies and Fletcher (1987) noted that 0-30% levels of parasitism are typical.

Parasitoids of *B. cucurbitae* include: *Biosteres angaleti* attacking larvae in Sabah; *Biosteres arisanus*; *Biosteres longicaudatus* attacking larvae in southeast Asia and Hawaii; *Diachasmimorpha hageni* attacking larvae in Fiji; *Diachasmimorpha tryoni* attacking larvae in Hawaii; *Dirhinus anthracina* attacking pupae in East Africa, West Africa and Hawaii; *Neoaplectana carpocapsae*; *Opius fletcheri* attacking larvae in India, Malaysia, Philippines, Thailand, Sri Lanka, Guam and Hawaii; *Pysttalia incisi* attacking larvae in India, Indonesia, Malaysia, Philippines and Thailand; *Spalangia endius* attacking pupae in Philippines and Hawaii; *Spalangia hirta* attacking pupae in North America and Hawaii;

Tetrastichus dacicida attacking larvae in Africa and Hawaii; and *Tetrastichus giffardianus* attacking larvae in South Africa and Hawaii (Waterhouse, 1993b; Wharton and Gilstrap, 1983).

The utilization of pre-harvest management practices is important to reduce direct losses and to increase efficacy of post-harvest quarantine treatments. Since the discovery of the melon fly in Hawaii a number of methods have been employed in attempts to reduce or prevent damage by this pest. They include mechanical control, cultural control, biological control, and chemical control (Ronald and Jayma, 1991).

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***Bactrocera dorsalis* (Hendel, 1912) [Diptera: Tephritidae]**

Synonyms and changes in combination: *Bactrocera conformis* Doleschall, 1858; *Bactrocera ferrugineus* Fabricius; *Chaetodacus dorsalis* Hendel; *Chaetodacus ferrugineus* Fabricius; *Chaetodacus ferrugineus dorsalis* Hendel; *Chaetodacus ferrugineus okinawanus* Shiraki, 1933; *Dacus dorsalis* Hendel, 1912; *Dacus ferrugineus* Fabricius; *Dacus ferrugineus dorsalis* Fabricius; *Dacus ferrugineus okinawanus* Shiraki; *Dacus ferrugineus* var. *dorsalis* Fabricius; *Musca ferruginea* Fabricius, 1794; *Strumeta dorsalis* Hendel; *Strumeta ferrugineus* Fabricius.

Common name(s): Oriental fruit fly.

Host(s): *Bactrocera dorsalis* is a very serious pest of a wide variety of fruits and vegetables throughout its range and damage levels can be anything up to 100% of unprotected fruit. In China, where the pest populations are definitely the true *B. dorsalis*, the major hosts are apple, guava, mango, peach and pear (*Pyrus communis*) (X.-J. Wang, unpublished data, 1988, as reported in White and Elson-Harris, 1994). Due to the confusion between *B. dorsalis* and related species in the Oriental fruit fly species complex (some 52 species that are found in the Oriental region, and a further 16 species native to Australasia), there are very few published host records which definitely refer to true *B. dorsalis* (CABI, 2002).

Mangosteen has not been listed as a primary or secondary host of *B. dorsalis* in CABI (2002). No host plant survey has yet been carried out to show which hosts are of particular importance within the Asian range of true *B. dorsalis*.

Recorded commercial hosts are: *Aegle marmelos* (bael fruit), *Anacardium occidentale* (cashew nut), *Annona reticulata* (bullock's heart), *Annona squamosa* (sugar apple), *Areca catechu* (betelnut palm), *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), *Capsicum annuum* (bell pepper, capsicum), *Chrysophyllum cainito* (star-apple), *Citrus maxima* (pummelo), *Citrus reticulata* (mandarin), *Coffea arabica* (arabica coffee), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Dimocarpus longan* (longan), *Ficus racemosa* (cluster fig), *Litchi chinensis* (lychee), *Malus pumila* (paradise apple), *Mangifera foetida* (bachang mango), *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Mimusops elengi* (Asian bulletwood), *Momordica charantia* (bitter gourd), *Muntingia calabura* (Jamaica cherry), *Musa* sp. (banana, plantain), *Nephelium lappaceum* (rambutan), *Persea americana* (avocado), *Prunus armeniaca* (apricot), *Prunus avium* (gean, wild cherry), *Prunus cerasus* (sour cherry), *Prunus domestica* (plum, prune), *Prunus mume* (Japanese apricot tree), *Prunus persica* (peach), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Pyrus communis* (European pear), *Syzygium aqueum* (water apple), *Syzygium aromaticum* (clove), *Syzygium cumini* (jambolan), *Syzygium jambos* (rose apple), *Syzygium malaccense* (Malay apple), *Syzygium samarangense* (wax apple), *Terminalia catappa* (beach almond), *Ziziphus jujuba* (jujube) and *Ziziphus mauritiana* (Chinese date) (Allwood *et al*., 1999; Tsuruta *et al*., 1997).

Plant part(s) affected: Fruit (CABI, 2002).

Distribution: The true *Bactrocera dorsalis* is restricted to mainland Asia (except the peninsula of southern Thailand and West Malaysia), plus Taiwan and its adventive population in Hawaii (Drew and Hancock, 1994). CABI (2002) also includes California and Florida, USA, in the distribution because the fly is repeatedly trapped there in small numbers. The distribution of *B. dorsalis* was mapped by IIE (1994).

Bactrocera dorsalis is a serious pest of a wide range of fruit crops in Taiwan, southern Japan, China and in the northern areas of the Indian subcontinent, and it has also been

established in the Hawaiian Islands since about 1945 (Pemberton, 1946). Due to the confusion between *B. dorsalis* and related species in Malaysia, the Philippines, Indonesia, southern India and Sri Lanka, there are very few published host records which definitely refer to *B. dorsalis*, as opposed to misidentifications of related species within the *B. dorsalis* species complex. In Asia, *B. dorsalis* is recorded from Bangladesh (IIE, 1994); Bhutan (Drew and Hancock, 1994); Cambodia (Drew and Hancock, 1994; Waterhouse, 1993); China (Drew and Hancock, 1994); Guam (Waterhouse, 1993); Hawaii (Drew and Hancock, 1994); Laos (Drew and Hancock, 1994); Myanmar (Drew and Hancock, 1994); Nauru (Waterhouse, 1993) Nepal (Drew and Hancock, 1994); Pakistan (Drew and Hancock, 1994); Sri Lanka (Drew and Hancock, 1994); Thailand (Drew and Hancock, 1994; Waterhouse, 1993) and Vietnam (Drew and Hancock, 1994).

Biology: The eggs of *B. oleae* were described in detail by Margaritis (1985) and those of other species are probably very similar. They are 0.8 mm long, 0.2 mm wide, and white to yellow-white in colour (Margaritis, 1985). Females lay a number of eggs per fruit. Clutch sizes of 3-30 eggs have been recorded for *B. dorsalis* (Fletcher, 1989). Eggs of *B. dorsalis* are laid below the skin of the host fruit. These hatch within a day (although this can be delayed up to 20 days in cool conditions) and the larvae feed for another 6-35 days, depending on the season. Eggs are visible to the naked eye (CABI, 2002). Third instar larva of *B. dorsalis* are medium-sized, length 7.5-10 mm; width 1.5-2 mm (White and Elson-Harris, 1994).

Pupariation is in the soil under the host plant for 10-12 days but may be delayed for up to 90 days under cool conditions (Christenson and Foote, 1960). Pupae are barrel-shaped with most larval features unrecognisable. Puparium are usually about 60-80% length of larva. Pupae can be found in the growing medium, accompanying plants, and are also visible to the naked eye, being white to yellow-brown in colour. Other plant parts are not known to carry the pest in trade/transport (CABI, 2002). Fruits and growing media are liable to carry pupae of this fruit fly in trade/transport (CABI, 2002).

Adults are predominantly black or dark fuscous, or a balanced mixture of black and yellow. When the thorax is viewed dorsally, there are a number of pale whitish to yellow lateral stripes over the anterior plates. In addition, the posterior thoracic plates are black with orange to red-brown areas, or black. The abdomen is oval or parallel sided with a mediolateral dark stripe running most of its length (Carrol *et al*., 2002). Adults occur throughout the year and begin mating after about 8-12 days, and may live 1-3 months depending on temperature (up to 12 months in cool conditions) (Christenson and Foote, 1960). Adults may live for many months and in laboratory studies, the potential fecundity of females of *B. dorsalis* is well over 1000 eggs (Fletcher, 1989).

The major means of movement and dispersal are transportation of infected fruit and adult flight (Fletcher, 1989). Many *Bactrocera* spp. can fly 50-100 km (Fletcher, 1989).

Little information is available on the attack time for most fruits but few *Bactrocera* spp. attack prior to ripening (CABI, 2002). Fruit show the following symptoms of infestation, some necrosis around the puncture mark ('sting') following oviposition, which causes decomposition of the fruit that appears as black or brown lesions. Premature drop from trees can occur (CABI, 2002).

Control: Fruits (locally grown or samples of fruit imports) should be inspected for puncture marks and any associated necrosis. Suspect fruits should be cut open and checked for larvae. Larval identification is difficult, so if time allows, mature larvae should be transferred to saw dust (or similar dry medium) to allow pupation. Upon emergence, adult flies must be fed with sugar and water for several days to allow hardening and full colour to develop, before they can be identified (CABI, 2002). One of the most effective control techniques against fruit flies in general is to wrap fruit, either in newspaper, a paper bag, or in the case of long/thin fruits, a polythene sleeve. This is a simple physical barrier to oviposition but it has to be applied well before the fruit is attacked.

Larvae of *Bactrocera* spp. can be attacked either by parasitoids or by vertebrates eating fruit (either on the tree or as fallen fruit). Parasitoids appear to have little effect on the populations of most fruit flies and Fletcher (1987) noted that 0-30% levels of parasitism are typical. Mortality due to vertebrate fruit consumption can be very high as can puparial mortality in the soil, either due to predation or environmental mortality (White and Elson-Harris, 1994). To date, there are no records of biological control success for any *Bactrocera* or *Dacus* spp. (Wharton, 1989). However, Clausen (1978) reviewed the numerous releases that have taken place in Hawaii and these are listed under natural enemies. Clausen (1978) noted that any benefit was almost entirely due to *Fopius arisanus* (as *Opius oophilus*) and gave the example of guava fruit attack being reduced from 100 to 22% as a result of reduction in *B. dorsalis* populations through the effects of parasitism. A number of parasitoids were also released in Guam against *B. dorsalis* (Waterhouse, 1993).

Due to difficulties in verifying the identifications of both parasitoids and (in some cases) the fruit fly hosts, no attempt has been made to catalogue all natural enemy records (CABI, 2002). Major sources are listed in White and Elson-Harris (1994).

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Mealybugs

***Ferrisia virgata* (Cockerell, 1893) [Hemiptera: Pseudococcidae]**

Synonyms and changes in combination: *Dactylopius ceriferus* Newstead; *Dactylopius dasylirii* Cockerell; *Dactylopius magnolicida* King; *Dactylopius segregatus* Cockerell; *Dactylopius setosus* Hempel; *Dactylopius talini* Green; *Dactylopius virgatus* Cockerell; *Dactylopius virgatus farinosus* Cockerell; *Dactylopius virgatus humilis* Cockerell; *Dactylopius virgatus madagascariensis* Newstead; *Ferrisiana setosus* Ali; *Ferrisiana virgata* Takahashi; *Heliococcus malvastras* McDaniel; *Heliococcus malvastrus* McDaniel; *Pseudococcus bicaudatus* Keuchenius; *Pseudococcus ceriferus* Newstead; *Pseudococcus dasylirii* Fernald; *Pseudococcus magnolicida* Cockerell; *Pseudococcus marchali* Vayssière; *Pseudococcus segregatus* (Cockerell); *Pseudococcus segregatus* Fernald; *Pseudococcus setosus* Hempel; *Pseudococcus talina* Green; *Pseudococcus virgatus* (Cockerell); *Pseudococcus virgatus farinosus* Cockerell; *Pseudococcus virgatus humilis* Fernald; *Pseudococcus virgatus madagascariensis* Lindinger; *Pseudococcus virgatus* Kirkaldy.

Common name(s): Cotton scale; grey mealybug; guava mealybug; spotted mealybug; striped mealybug; tailed coffee mealybug; tailed mealybug; white-tailed mealybug.

Host(s): *Ferrisia virgata* is one of the most highly polyphagous mealybugs known, attacking plant species belonging to some 150 genera in 68 families (CABI, 2002). Many of the host species belong to the Leguminosae and Euphorbiaceae.

Hosts include: *Abelmoschus esculentus* (okra), *Abutilon mauritianum*, *Acacia farnesiana* (sweet acacia), *Acacia pennata*, *Acalypha hispida* (chenille plant), *Acalypha indica* (Indian nettle), *Acalypha grandis*, *Acalypha* sp. (copperleaf), *Achyranthes aspera* var. *aspersa* (devil's horsewhip), *Agave* sp., *Albizia niopoides*, *Albizia* sp., *Alocasia* sp. (elephant's ear), *Alternanthera amabilis*, *Alternanthera versicolor*, *Amaranthus* sp. (amaranth, pigweed), *Amaranthus viridis* (green amaranth), *Amphilophium paniculatum* (liana de cuello), *Amphimas pterocarpoides*, *Anacardium occidentale* (cashew), *Ananas comosus* (pineapple), *Andira inermis* (cabbage bark), *Annona* sp. (custard apple), *Annona cherimola* (custard apple), *Annona muricata* (soursop), *Annona reticulata* (bullock's heart), *Annona squamosa* (sugar apple), *Arachis hypogaea* (groundnut, peanut), *Artocarpus altilis* (breadfruit), *Asparagus plumosus* (asparagus fern), *Bauhinia* sp., *Bixa orellana* (annatto), *Caesalpinia bonduc* (gray nicker), *Caesalpinia crista*, *Caesalpinia pulcherrima* (paradise flower), *Cajanus cajan* (pigeon pea), *Calliandra haematocephala* (red powderpuff),

Calpurnia sp., *Camellia japonica* (camellia), *Canna indica* (Indian shot), *Canthium glabriflorum*, *Carica papaya* (pawpaw), *Casuarina equisetifolia* (beach she-oak), *Casuarina oligodon*, *Cestrum* sp., *Citrus aurantium* (Seville orange), *Citrus limon* (lemon), *Citrus* × *paradisi* (grapefruit), *Citrus* sp., *Cleome rutidosperma* (fringed spiderflower), *Clinogyne leucantha*, *Coccoloba uvifera* (Jamaican kino), *Cocos nucifera* (coconut), *Codiaeum* sp. (croton), *Codiaeum variegatum* (garden croton), *Coffea arabica* (arabica coffee), *Coffea canephora* (robusta coffee), *Cola* sp., *Coldenia plicata*, *Coldenia* sp., *Colocasia esculenta* (taro), *Corchorus* sp. (jute), *Cordyline fruticosa* (good-luck plant), *Crescentia* sp., *Croton* sp., *Cucurbita maxima* (giant pumpkin), *Cucurbita pepo* (ornamental gourd), *Cyathula prostrata* (pastureweed), *Cyrtosperma merkusii* (giant swamp taro), *Datura metel* (downy thorn-apple), *Desmodium abyssinica*, *Dieffenbachia* sp. (dumb cane), *Duranta erecta* (golden dewdrop), *Erythrina fusca* (coral-bean), *Erythrina variegata* (Indian coral tree), *Euphorbia pulcherrima* (poinsettia), *Erythroxylum tortuosum*, *Ficus macbridei*, *Ficus palmeri* (rock fig), *Ficus virens* (spotted fig), *Fraxinus* sp. (ash), *Gardenia jasminoides* (Cape jasmine), *Glycine max* (soybean), *Gossypium* sp. (cotton), *Gochnatia pulchra*, *Graptophyllum* sp., *Grevillea robusta* (silky oak), *Guettarda speciosa* (beach gardenia), *Hallea stipulosa* (abura), *Herrania nitida*, *Hevea brasiliensis* (rubber tree), *Hibiscus mutabilis* (Confederate rose), *Hibiscus rosa-sinensis* (Chinese hibiscus), *Hippomane* sp., *Hymenopappus* sp., *Indigofera hirsuta* (hairy indigo), *Inga* sp., *Inocarpus fagifer* (Tahiti chestnut), *Ipomoea hederacea* (ivy-leaf morning glory), *Iris* sp. (flag, sword lily), *Ixora* sp. (jungle flame), *Jacaranda* sp., *Jatropha* sp., *Laguncularia racemosa* (white mangrove), *Lantana* sp., *Lantana camara* (lantana), *Lawsonia inermis* (henna), *Lecythis* sp., *Leucaena leucocephala* (horse tamarind), *Lindenia rivalis*, *Litchi chinensis* (lychee), *Lycopersicon esculentum* (tomato), *Macaranga heudolotii*, *Maclura* sp., *Magnolia* sp., *Malus domestica* (apple), *Malvastrum* sp. (false mallow), *Mandevilla* sp., *Mangifera indica* (mango), *Manihot aesculifolia*, *Manihot carthaginensis*, *Manihot carthagenensis* subsp. *glaziovii* (Ceara rubber tree), *Manihot esculenta* (cassava), *Manilkara* sp., *Matisia paraensis*, *Medicago sativa* (alfalfa, lucerne), *Mimosa pudica* (sensitive plant), *Mimusops elengi* (medlar), *Mimusops* sp. (milkwood), *Morinda citrifolia* (Indian mulberry, rotten cheesefruit), *Morus* sp. (mulberry), *Murdannia nudiflora* (naked stem dewflower), *Musa paradisiaca* (banana), *Musa* sp. (banana, plantain), *Nephthytis* sp., *Nerium oleander* (oleander), *Nesogordonia papaverifera*, *Olea* sp. (olive), *Parthenium hysterophorus* (parthenium weed), *Pelargonium* sp., *Persea americana* (avocado), *Persea americana* var. *americana* (avocado), *Phaseolus* sp. (bean), *Phyllanthus niruri* (niruri), *Phoenix dactylifera* (date palm), *Piper guineense* (West African black pepper), *Pithecellobium dulce* (Manila tamarind), *Plumeria rubra* (frangipani), *Plumeria rubra* f. *acutifolia* (Mexican frangipani), *Portulaca* sp., *Primula* sp. (primrose), *Prosopis juliflora* (mesquite), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Rheum rhaponticum* (garden rhubarb), *Rhoeidum microphyllum*, *Rhynchospora cephalotes*, *Ricinodendron africanum* (nsasana), *Rosa* sp. (rose), *Saccharum officinarum* (sugarcane), *Salvadora persica* (toothbrush tree, mustard tree), *Salvia reflexa* (mintweed), *Samanea*

saman (monkey pod), *Senna gaudichaudiii* (kolomona), *Sesbania* sp., *Solanum biflorum*, *Solanum melongena* (aubergine, eggplant), *Solanum tuberosum* (potato), *Sophora tomentosa* (silverbush), *Spathiphyllum* sp., *Spathodea campanulata* (African tulip tree), *Spondias purpurea* (hog-plum), *Synedrella nodiflora* (Cinderella weed), *Syzygium samarangense* (wax apple), *Tabebuia* sp. (trumpet tree), *Tagetes minuta* (Mexican marigold), *Tephrosia purpurea* (purple tephrosia), *Terminalia catappa* (Indian almond, tropical almond), *Terminalia superba* (ofram, shinglewood), *Theobroma cacao* (cocoa), *Theobroma subincatum*, *Toxicodendron radicans* (poison ivy), *Tribulus cistoides* (Jamaican feverplant), *Urera* sp., *Vigna unguiculata* (cowpea), *Viola* sp. (pansy, violet), *Vismia baccifera*, *Vitis vinifera* (wine grape), *Vochysia* sp., *Waltheria ovata* (velvet shrub), *Xanthosoma sagittifolium* (tannia), *Zingiber officinale* (ginger), *Ziziphus spina-christi* (Christ's thorn) (Ben-Dov *et al*., 2001); *Dracaena* sp., *Elaeis guineensis* (African oil palm), *Ipomoea batatas* (sweet potato), *Malpighia punicifolia* (Barbados cherry tree), *Nicotiana tabacum* (tobacco), *Piper betle* (betel pepper), *Piper nigrum* (black pepper), *Solanum nigrum* (black nightshade), *Zea mays* (corn, maize) (CABI, 2002).

Plant part(s) affected: Fruit, leaf, shoot, and in dry conditions, the roots of hosts (Schreiner, 2000). This pest can get under the calyx of fruits and cause scarring (Schreiner, 2000).

Distribution: Angola (CABI, 2002); Antigua and Barbuda (Ben-Dov *et al*., 2001); Argentina (Ben-Dov *et al*., 2001); Australia (Northern Territory, Queensland) (Ben-Dov *et al*., 2001) (AgWA (2003) states that it is not in Western Australia); Bahamas (Ben-Dov *et al*., 2001); Bangladesh (CABI, 2002); Barbados (CABI, 2002); Belau (CABI, 2002); Belize (Ben-Dov *et al*., 2001); Bermuda (Ben-Dov *et al*., 2001); Bolivia (Ben-Dov *et al*., 2001); Brazil (Ben-Dov *et al*., 2001); Brunei Darussalam (CABI, 2002); Cambodia (Ben-Dov *et al*., 2001; CABI, 2002); Cameroon (CABI, 2002); Cayman Islands (Ben-Dov *et al*., 2001); China (Ben-Dov *et al*., 2001); Colombia (Ben-Dov *et al*., 2001); Comoros (Ben-Dov *et al*., 2001); Congo Democratic Republic (Ben-Dov *et al*., 2001); Cook Islands (Ben-Dov *et al*., 2001); Costa Rica (Ben-Dov *et al*., 2001); Côte d'Ivoire (Ben-Dov *et al*., 2001); Cuba (Ben-Dov *et al*., 2001); Dominica (Ben-Dov *et al*., 2001); Ecuador (Galapagos Islands) (Ben-Dov *et al*., 2001); Egypt (CABI, 2002); Ethiopia (CABI, 2002); Fiji (Ben-Dov *et al*., 2001); France (Ben-Dov *et al*., 2001); French Polynesia (Ben-Dov *et al*., 2001); Ghana (Ben-Dov *et al*., 2001); Guatemala (Ben-Dov *et al*., 2001); Guyana (Ben-Dov *et al*., 2001); Haiti (CABI, 2002); Honduras (Ben-Dov *et al*., 2001); India (Ben-Dov *et al*., 2001); Indonesia (Ben-Dov *et al*., 2001); Jamaica (Ben-Dov *et al*., 2001); Japan (Ben-Dov *et al*., 2001); Kenya (Ben-Dov *et al*., 2001); Kiribati (Ben-Dov *et al*., 2001); Laos (CABI, 2002); Madagascar (Ben-Dov *et al*., 2001); Malawi (CABI, 2002); Malaysia (CABI, 2002); Marshall Islands (Ben-Dov *et al*., 2001); Martinique (Ben-Dov *et al*., 2001); Mauritius (Rodrigues Island) (Ben-Dov *et al*., 2001; CABI, 2002); Mexico (Ben-Dov *et al*., 2001); Micronesia, Federated States of (Yap) (Ben-Dov *et al*., 2001); Mozambique (CABI, 2002); Myanmar (CABI, 2002); Netherlands Antilles (CABI, 2002); New

Caledonia (Ben-Dov *et al*., 2001); Nicaragua (Ben-Dov *et al*., 2001); Nigeria (CABI, 2002); Northern Mariana Islands (Ben-Dov *et al*., 2001); Pakistan (CABI, 2002); Palau (Ben-Dov *et al*., 2001); Panama (Ben-Dov *et al*., 2001); Papua New Guinea (Ben-Dov *et al*., 2001); Paraguay (Ben-Dov *et al*., 2001); Peru (Ben-Dov *et al*., 2001); Philippines (Ben-Dov *et al*., 2001); Puerto Rico (Ben-Dov *et al*., 2001); (Ben-Dov *et al*., 2001); Saint Kitts and Nevis (Ben-Dov *et al*., 2001); Samoa (CABI, 2002); Sao Tome and Principe (CABI, 2002); Saudi Arabia (Ben-Dov *et al*., 2001); Senegal (CABI, 2002); Seychelles (Ben-Dov *et al*., 2001); Sierra Leone (CABI, 2002); Singapore (CABI, 2002); Solomon Islands (Ben-Dov *et al*., 2001); Somalia (CABI, 2002); South Africa (Ben-Dov *et al*., 2001); Spain (La Rioja) (Ben-Dov *et al*., 2001); Sri Lanka (Ben-Dov *et al*., 2001); Sudan (Ben-Dov *et al*., 2001); Suriname (Ben-Dov *et al*., 2001); Taiwan (Ben-Dov *et al*., 2001); Tanzania (Ben-Dov *et al*., 2001); Thailand (Ben-Dov *et al*., 2001); Tonga (Ben-Dov *et al*., 2001); Trinidad and Tobago (Ben-Dov *et al*., 2001); Tuvalu (Ben-Dov *et al*., 2001); Uganda (Ben-Dov *et al*., 2001); United Arab Emirates (CABI, 2002); United States (California, District of Columbia, Florida, Louisiana, Maryland, Massachusetts, New Jersey, New Mexico, New York, Ohio, Pennsylvania, Texas, Virginia) (Ben-Dov *et al*., 2001); United States Minor Outlying Islands (Wake Island) (Ben-Dov *et al*., 2001); Vanuatu (Ben-Dov *et al*., 2001); Venezuela (Ben-Dov *et al*., 2001); Vietnam (Ben-Dov *et al*., 2001); Western Samoa (Ben-Dov *et al*., 2001); Yemen (CABI, 2002); Zambia (CABI, 2002); Zimbabwe (CABI, 2002).

Biology: Adult female are oval, yellow/green in colour and 4-4.5 mm long. When viewed dorsally, there are two dark stripes down their length. These show through the waxy secretion that covers their body (CABI, 2002). Waxy threads extend from the body in all directions and there are two long wax tails.

The life history of *F. virgata* was studied in Iraq on potato sprouts or *Acalypha wilkesiana* (copperleaf). Eggs were laid singly and the incubation period averaged 2.11-2.62 hours. Percentage hatch ranged from 96.2 to 99.1. Total duration of the nymphal stage in females averaged 43.2 and 92.6 days at 28.9 and 16.6ºC, respectively, while in males it averaged 25.4 days at 25.1-26.5ºC. The mortality rate observed during the nymphal stages in the autumn-winter generations was higher than that of the spring-summer ones; these rates were 14.3-100% and 0-23%, respectively. The total life-span, from the egg stage to the end of the adult stage, averaged 76-154 days in females as opposed to 19-47 days in males. The number of eggs laid by a single female averaged 64-78, and these eggs resulted in 61-67 nymphs. The average number of eggs laid per female per day was 3.4-4.5 (Awadallah *et al*., 1979).

The biology of *F. virgata* was investigated in the Philippines on several vegetables and ornamental plants. This pest was most abundant from February to May and was observed feeding on 76 species of plants belonging to 33 families. Specimens reared on *Gardenia jasminoides* in the laboratory showed that there were three nymphal instars and that the

total nymphal period was 45-64 days. The lifespan of the adult female was 12-31 days (Lapis, 1970).

On *Citrus* spp. in South Africa, adults and larvae damage their host plant by sucking sap and excreting honeydew onto the fruit and leaves, leading to sooty mould growth that interferes with photosynthesis (Cilliers and Bedford, 1978). Mealybugs often form dense colonies on plants, making it difficult to distinguish individual insects. Heavy infestations by these species may severely stunt the growth of young trees. Infestations on young fruit result in the fruit turning yellow and eventually dropping off the tree (Cilliers and Bedford, 1978). Late infestations on larger fruit can result in yellow spots at feeding areas or in fruit distortion (Cilliers and Bedford, 1978).

The main dispersal stage of mealybugs is the first instar, or crawler (CABI, 2002). Dispersal by crawlers is limited to one plant or adjacent plants if they are touching. However, crawlers can be carried between plants and sites by wind or on larger animals including man, and all life cycle stages can be transported on ornamental plants, propagation material or produce (CABI, 2002). This pest can walk, however they do not generally move very far and therefore large clusters of insects may congregate on a host (Schreiner, 2000).

Control: The application of oil soap and/or insecticide reduced the number of scale insects and mealybugs in citrus by 93-100% (Baker and Shearin, 1992; Beattie and Ribbon, 1980; Lindquist, 1981); and with the same efficacy (93-100%) for grapevine (Su and Wang, 1988).

A 30-second dip in engine oil during post-harvest processing was found to be effective in eliminating live mealybugs, mites and thrips from *Citrus* spp. (Bailey and Brown, 1999). The efficacy of a post-harvest oil dip to control arthropod pests such as mealybugs, light brown apple moth and mites, was found to be 95-100%, depending on the oil concentration used (Bailey and Brown, 1999; Taverner and Bailey, 1995). When mealybug infestation was less than 6%, a combination of insecticidal soap and insecticide can kill all the mealybug survivors remaining after harvest (Hata *et al*., 1992).

Parasitoids of *F. virgata* include: *Aenasius advena* attacking nymphs and adults in Congo, India, South Africa, Mexico and Hawaii; *Anagyrietta brevicornis*, *Anagyrus brevicornis*, *Anagyrus qadrii* attacking nymphs and adults in India; *Anaysis alcocki* attacking nymphs and adults in the Philippines; *Anusioptera aureocincta* and *Pseudaphycus debachi* attacking nymphs and adults in Mexico; *Blepyrus insularis* attacking nymphs in India, South Africa, Mexico and Congo; *Coelinius* spp. attacking larvae in Japan; *Gyranusoidea citrina* attacking nymphs in South Africa and Kenya; *Myiopharus doryphorae* attacking nymphs and adults; and *Patiyana coccorum* attacking nymphs and adults in Bangladesh (Bartlett, 1978).

Predators of *F. virgata* include: *Alloagrapta javana*, *Chrysopa orestes*, *Mallada boninensis*

and *Scymnus coccivora* attacking eggs, larvae, nymphs, pupae and adults in India; *Alloagrapta obliqua*, *Azya luteipes* and *Olla v-nigrum* attacking eggs, larvae, nymphs, pupae and adults in Hawaii; *Chilomenes sexmaculata* attacking nymphs and adults in the Philippines; *Chrysopa flaveola*, *Scymnus apiciflavus* and *S. roepkei* attacking nymphs and adults; *Cryptolaemus montrouzieri* attacking eggs, larvae, nymphs, pupae and adults in India and Indonesia; *Exochomus flaviventris* and *Hyperaspis senegalensis hottentotta* attacking eggs, larvae, nymphs, pupae and adults in Congo; *Nephus regularis* and *Triommata coccidivora* attacking nymphs and adults in India; *Ocyptamus argentinus* attacking eggs, larvae, nymphs, pupae and adults in Brazil; and *Scymnus castaneus* attacking eggs, larvae, nymphs, pupae and adults in Pakistan and Bangladesh (Bartlett, 1978).

Pathogens of *F. virgata* include *Entomophthora fresenii* which attacks nymphs and adults (Bartlett, 1978).

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***Planococcus litchi* Cox [Hemiptera: Pseudococcidae]**

Synonyms and changes in combination: None.

Common name(s): Mealybug.

Host(s): *Eriobotrya japonica* (loquat) (Cox, 1989); *Litchi chinensis* (lychee) (Ben-Dov *et al*., 2001). This species is most commonly found on lychees (Cox, 1989).

Plant part(s) affected: Lychee fruit (Cox, 1989).

Distribution: China (Hong Kong), Japan, Philippines, Thailand (Ben-Dov *et al*., 2001; Cox, 1989).

Biology: There is limited published information on the biology of *Planococcus litchi*. However, information regarding *Planococcus lilacinus*, a species from the same genus, is outlined below.

Adults of female *P. litchi* are oval in shape, 1.3-2.7 mm long and 0.7-0.2 mm wide (when slide mounted). Pairs of short setae are positioned around the lateral margin of this

mealybug (Cox, 1989).

On durian in Malaysia, females of *P. lilacinus* lay 600-800 eggs in clusters of 100-200 over about 14 days (Ooi *et al*., 2002). Eggs hatch in 6-10 days. Nymphs move around until they find a good feeding site or finish developing into adults (Ooi *et al*., 2002). Females have 3 nymphal stages and 2-3 generations are produced per year. In India, females reportedly laid 55-152 eggs in a white cottony envelope on the stem or leaf petioles of cauliflower. The eggs hatched within 24 hours. The nymphal period was 20-25 days. Severe infestation caused stunted plant growth, withering and reduced flower size (Loganathan and Suresh, 2001).

Planococcus spp. in general feed on branches, inflorescences and fruits of durian (Ooi *et al*., 2002). Infestation increases due to ant tending, and damaged plants become stunted and covered in sooty mould. Mealybugs attack the durian fruit epidermis rather than the flesh as their proboscis is not strong enough to penetrate this membrane (Ooi *et al*., 2002). Infested fruits are considered low quality and are non-marketable. In eastern Thailand this pest attacks durian after fruit set during the beginning of the hot and dry season starting in March. Infestation continues until the fruits mature in mid July (Ooi *et al*., 2002).

The main dispersal stage for mealybugs is the first instar or crawler. Dispersal by crawlers is limited to one plant or adjacent plants if they are touching. However, crawlers can be carried between plants and sites by wind or on larger animals including man, and all life cycle stages can be transported on ornamental plants, propagation material or produce (CABI, 2002).

P. litchi is most commonly intercepted on lychee fruit imported into the USA and the UK (Cox, 1989).

Control: Control methods for *P. litchi* could not be found. However, chemical control methods for *Planococcus lilacinus*, a species from the same genus, is outlined below.

In India, a field trial conducted to evaluate 7 insecticides and coconut oil showed that monocrotophos was the best, followed by coconut oil treatment (Dhandapani *et al*., 1992). In India, soil application of dimethoate was the best of several systemic insecticides tested (Kumar and Prakasan, 1992). Other compounds found to be effective against *P. lilacinus* in India were a combination of kerosene and parathion-methyl, kerosene alone (Kumar *et al*., 1989) and monocrotophos (integrated with the release of *C. montrouzieri*). The insecticides fenthion, phosphamidon, quinalphos, dimethoate, phosalone and endosulfan, in descending order of effectiveness, also gave good control (CABI, 2002).

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Soft scales

Coccus viridis Green, 1889 [Hemiptera: Coccidae]

Synonyms and changes in combination: *Lecanium viride* Green; *Coccus viridis* (Green); *Lecanium* (*Trechocorys*) *hesperidum africanum* Newstead (nomen nudum); *Lecanium* (*Coccus*) *viride* (Green); *Coccus viridis bisexualis* Köhler (nomen nudum); *Coccus viridis viridis* Köhler (nomen nudum); *Eulecanium viridis* (Green); *Lecanium viridis* (Green).

Common name(s): Green coffee scale, green scale, soft green scale.

Host(s): *Aegle marmelos* (bael tree), *Aegle* sp., *Aeglopsis chevalieri* (Chevalier's aeglopsis), *Afraegle paniculata* (Nigerian powder flask fruit), *Alpinia purpurata* (red ginger), *Alpinia* sp. (ornamental ginger), *Alstonia macrophylla* (devil tree), *Alyxia stellata* (maile), *Ananas comosus* (pineapple), *Annona* sp. (custard apple), *Antidesma bunius* (bignay, Chinese laurel), *Apium graveolens* (celery), *Aralia* sp., *Arctotis* sp. (African daisy), *Ardisia crispa*, *Areca catechu* (betel palm), *Atalantia citrioides* (Cochin China atalantia), *Barringtonia asiatica* (fish-killer tree), *Balsamocitrus dawei* (Uganda powder flask fruit), *Bobea mauaii*, *Boninia grisea*, *Broughtonia* sp., *Brunfelsia nitida*, *Bryophyllum pinnatum* (miracle leaf), *Bryophyllum* sp., *Caladium* sp., *Callicarpa lanata*,

Camellia sinensis (tea), *Campnosperma brevipetiolatum*, *Canthium odoratum* (sweet Suzie), *Carissa carandas* (karanda), *Carissa macrocarpa* (Natal plum), *Carissa* sp., *Cassia* sp., *Cestrum* sp., *Chiococca alba* (West Indian snowberry), *Chrysophyllum cainito* (star-apple), *Cinchona calisaya* (quinine), *Cinchona pubescens* (redbark), *Cinchona* sp., *Citropsis articulata* (West African cherry-orange), *Citrus aurantifolia* (lime), *Citrus aurantium* (Seville orange), *Citrus decumana*, *Citrus hystrix* (kaffir lime), *Citrus limon* (lemon), *Citrus maxima* (shaddock), *Citrus nobilis* (tangor), *Citrus* × *paradisi* (grapefruit), *Citrus reticulata* (mandarin), *Citrus sinensis* (navel orange), *Citrus* sp., *Clausena excavata*, *Clausena lansium* (wampi), *Clausena lunulata*, *Clerodendrum* sp., *Clerodendron speciosissimum* (Java glorybower), *Coccoloba uvifera* (sea-grape), *Cocos nucifera* (coconut), *Cocos* sp. (coconut), *Codiaeum* sp. (croton), *Coffea arabica* (arabica coffee), *Coffea canephora* (robusta coffee), *Coffea liberica* (liberica coffee), *Coffea* sp., *Commelina* sp. (dayflower), *Cordia alba* (white manjack), *Cordia alliodora* (Spanish elm), *Cordia myxa* (Assyrian plum), *Cordia nitida* (red manjack), *Cordia* sp., *Cordyline fruticosa* (good-luck plant), *Croton* sp., *Cryptostegia grandiflora* (rubber vine), *Cucurbita pepo* (ornamental gourd), *Dimocarpus longan* (longan), *Dioscorea* sp. (yam), *Dodonaea* sp. (hopbush), *Dodonaea viscosa* (Florida hopbush), *Dovyalis* sp., *Dracaena* sp., *Ehretia tinifolia*, *Eucalyptus* sp. (gum tree), *Eugenia* sp., *Eugenia uniflora* (Surinam cherry), *Fallopia convolvulus* (black bindweed), *Faramea occidentalis* (false coffee), *Feroniella oblata*, *Ficus elastica* (Indian rubber tree), *Fitchia* sp., *Gardenia jasminoides* (Cape jasmine), *Gardenia* sp., *Gardenia taitensis* (Tahitian gardenia), *Genipa americana* (marmelade-box), *Gerbera* sp., *Gerbera jamesonii* (Transvaal daisy), *Gliricidia* sp., *Gomphrena globosa* (globe amaranth), *Heritiera littoralis* (looking glass mangrove), *Hibiscus* sp., *Hiptage benghalensis* (hiptage), *Hydrangea* sp., *Homalocladium platycladum* (ribbon bush), *Homalocladium* sp. (ribbon bush, tapeworm plant), *Ilex macrothyrsa*, *Ilex purpurea* (purple holly), *Inocarpus fagifer* (Tahiti chestnut), *Ixora chinensis* (Chinese ixora), *Ixora coccinea* (jungle geranium), *Ixora macrothyrsa*, *Ixora* sp. (jungle flame), *Justicia spicigera* (mohintli), *Lagerstroemia indica* (crape myrtle), *Lantana camara* (lantana), *Lissochilus* sp., *Litchi chinensis* (lychee), *Loranthus* sp., *Luvunga scandens* (Indian luvunga, lavanga), *Mammea americana* (mammee apple), *Mangifera indica* (mango), *Manihot carthagenensis* subsp. *glaziovii* (Ceara rubber tree), *Manihot esculenta* (cassava), *Manihot para*, *Manilkara zapota* (sapodilla), *Maytenus* sp., *Melaleuca* sp. (paperbark), *Melia azedarach* (chinaberry), *Melicoccus bijugatus* (Spanish lime), *Meryta macrophylla*, *Microcitrus australis* (Australian lime), *Mimusops* sp. (milkwood), *Moesa indica*, *Morinda citrifolia* (Indian mulberry), *Murraya paniculata* (orange jessamine), *Murraya* sp., *Myricaria* sp., *Myristica* sp. (nutmeg), *Myrtella* sp., *Naringi crenulata* (hesperethusa), *Nerium oleander* (oleander), *Nerium* sp. (oleander, rose laurel), *Ochrosia nakaiana*, *Odontonema* sp., *Palaquium formosanum* (Taiwan guayule), *Pandanus* sp. (screwpine), *Persea americana* (avocado), *Pisonia umbellifera* (bird-catcher tree), *Pittosporum* sp., *Pittosporum tobira* (Japanese mock orange), *Platanocephalus chinensis*, *Platanocephalus morindaefolius*, *Pluchea indica* (Indian camphorweed), *Plumeria rubra*

(frangipani), *Plumeria obtusa* (white frangipani), *Plumeria rubra* f. *acutifolia* (Mexican frangipani), *Plumeria rubra* f. *tricolor*, *Plumeria* sp. (frangipani, temple tree), *Podocarpus* sp. (plum vine), *Polyscias guilfoylei* (geranium aralia), *Polyscias* sp. (aralia, panax), *Poncirus trifoliata* (trifoliate orange), *Pouteria campechiana* (canistel), *Pouteria obovata*, *Pouteria sapota* (mammee sapote), *Pouteria* sp., *Psidium cattleianum* var. *littorale* (strawberry guava), *Psidium friedrichsthalianum* (wild guava), *Psidium guajava* (guava), *Psychotria boninensis*, *Psychotria laurifolia*, *Randia nigrescens*, *Randia tahitensis*, *Rauvolfia vomitoria* (poison devil's pepper), *Sanchezia speciosa*, *Scaevola taccada* (beach naupaka), *Schefflera* sp., *Schinus molle* (California pepper tree), *Schinus* sp., *Schinus terebinthifolius* (Brazilian pepper tree), *Senecio* sp., *Spermacoce tenuior* (slender false buttonweed), *Strychnos nux-vomica* (nux-vomica), *Swinglea glutinosa*, *Syzygium aromaticum* (clove), *Syzygium malaccense* (Malay apple), (Ben-Dov *et al*., 2001), *Tecoma capensis* (Cape honeysuckle), *Terminalia catappa* (Indian almond), *Theobroma cacao* (cacao), *Thevetia peruviana* (lucky nut, yellow oleander), *Timonius* sp., *Tipuana* sp., *Triphasia trifolia* (limeberry), *Verbena* sp. (vervain), *Zingiber officinale* (ginger) (Ben-Dov *et al*., 2001); *Anthurium* spp. (flamingo flower), Cycadaceae, Orchidaceae (Hansen *et al*., 1992); *Artocarpus* sp. (breadfruit) (CABI, 2002).

Plant part(s) affected: Fruit/pod, leaf, stem, twig (CABI, 2002). Leaves, twigs and fruit of lychee (Waite and Elder, 2000); leaves of *Ixora* spp. in Hawaii (Hansen *et al*., 1991); leaves of Florida citrus (Childers *et al*., 1987); lime fruits in India (Mani and Krishnamoorthy, 1996); and cut flowers and foliage of ornamental in Hawaii (Hansen *et al*., 1992).

Distribution: Australia (Queensland) (Ben-Dov *et al*., 2001; Waite and Elder, 2000) but not present in Western Australia (AgWA, 2003); Angola, Bermuda, Bonin Islands, Brazil, Cameroon, Cambodia, Cape Verde, China, Colombia, Comoros, Cook Islands, Côte d'Ivoire, Cuba, Dominican Republic, Egypt, El Salvador, Fiji, French Polynesia (Tahiti), Ghana, Guadeloupe, Guam, Guinea, Guyana, Honduras, India, Indonesia, Jamaica, Kenya, Kiribati, Madagascar, Madeira Islands, Martinique, Mauritius (Agalega Islands), Mexico, Nauru, Netherlands, New Caledonia, Nigeria, Northern Mariana Islands, Palau, Panama, Papua New Guinea, Peru, Philippines, Réunion, São Tome and Principe, Seychelles, Sierra Leone, Solomon Islands, South Africa, Sri Lanka, Taiwan, Tanzania, Thailand, Tonga, Tuvalu, Uganda, United States (Florida, Hawaii), Vanuatu, Vietnam, Wallis and Futuna Islands, Western Samoa, Zanzibar (Ben-Dov *et al*., 2001).

Biology: Eggs are whitish green in colour and elongate to oval in shape. Females generally lay single eggs at a time, beneath themselves, on the undersurface of host plant leaves (Fredrick, 1943). A few minutes to several hours after being laid, the eggs hatch, still beneath the female where they are protected (Fredrick, 1943). Nymphs are oval, flat and yellowish green in colour with six short legs. There are three nymphal stages prior to the adult and each stage is larger and more convex than the previous (Mau and Kessing, 1992).

Adults are bright green in colour with a brown or blackish, irregular, U-shaped, internal marking visible to the naked eye. The U-shaped marking is positioned lengthwise along the centre of the scale. Adults are somewhat oval in shape, quite flat and measure 15-10 mm in length. The front end is more rounded and the rear has a distinct cleft extending about ¼ of the way into the body. Dead scales are light brown or buff in colour and the black internal marking is absent (Mau and Kessing, 1992).

C. viridis is parthenogenetic and oviparous (Fredrick, 1943). In the United States, multiple generations develop per year (Fredrick, 1943). In Queensland, Australia it develops 3-4 generations per year (Ben-Dov *et al*., 2001). In south Florida, some adults were observed by Fredrick (1943) to complete egg deposition in 8 days, and others deposited eggs over a 42 day period. The length of time that passed from the egg to egg-depositing maturity during the late summer months was from 50-70 days (Fredrick, 1943). Eggs hatch into crawlers that wander around the host plant or disperse to other hosts. Once a suitable leaf or green shoot is found the nymphs settle, begin to feed and develop into adults. *C. viridis* usually remains in this same spot unless their position becomes unfavourable. The mature female does not move (Mau and Kessing, 1992). This pest is often found feeding along the main vein of the leaf and near the tips of green shoots of hosts, where it feeds from the phloem of the host plant. Damage due to the feeding of an individual scale is small. However, when large populations are present yellowing, defoliation, reduction in fruit set and loss in plant vigour are caused (LePelley, 1968). Honeydew is also produced by this pest. This sweet and watery excrement is fed on by bees, wasps, ants and other insects. The honeydew serves as a medium on which sooty mould fungus can grow. The sooty mould blackens the leaf and decreases photosynthesis; on fruit, it reduces the marketability of the fruit (Elmer and Brawner, 1975). *C. viridis* is especially damaging to young trees in the first two years after transplanting. It is a serious pest of coffee in many countries, so devastating at times that coffee production ceased (LePelley, 1968).

The main dispersal stage for mealybugs is the first instar or crawler. Dispersal by crawlers is limited to one plant or adjacent plants if they are touching. However, crawlers can be carried between plants and sites by wind or on larger animals including man, and all life cycle stages can be transported on ornamental plants, propagation material or produce (CABI, 2002).

Control: Scales are usually brought into greenhouse situations with the introduction of infested plant material. All plant material going into the greenhouse should be thoroughly inspected for scales and other insects before being introduced (Copland and Ibrahim, 1985).

Chemicals used on scales are usually the same as those used on mealybugs. Depending on the host, excellent control can be obtained with malathion, carbaryl, volck oil or methomyl. Carbaryl is particularly effective, but its residues are harmful to beneficial predators and parasites. As in the use of all chemicals, consult the label or a database for

crop registrations (Mau and Kessing, 1992).

Several entomogenous fungi were observed associated with green scale on citrus, and some apparently played an important role in the natural limitations of the scale on citrus during certain seasons of the year. In Florida, these fungi include the white-fringed fungus, *Verticillium* (*Cephalosporium*) *lecanii* (Zimmerman); *Aschersonia cubensis* (Cuban aschersonia); the pink scale fungus, *Nectria diploa*; and a greyish blue fungus The white-fringed fungus is the most common and apparently causes the highest percentage of mortality. All attempts to artificially spread or inoculate the fungus to healthy green scale were unsuccessful (Fredrick, 1943). The green scale is often associated with ants. Controlling ant populations help to reduce levels of this pest. Ants protect the green scales from lady beetles and other predators. In turn, the ants feed on the sweet honeydew excreted by the scales. Without the ants the green scale is more vulnerable to predation by beetles (Mau and Kessing, 1992).

Parasites of *C. viridis* include: *Aneristus ceroplaste*, *Coccophagus hawaiiensis*, *C. ochraceus*, *Microterys kotinskyi*, *Prococcophagus orientalis*, *Scutellista cyanea* and *Tomocera californica* (Zimmerman, 1948). Important lady beetle predators include: *Azya orbigera*, *Chilocorus circumdatus*, *Cryptolaemus montrouzieri* and *Orcus chalybeus*. These predators have exerted substantial control (Charanasri and Nishida, 1975; Clausen *et al*., 1978).

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***Drepanococcus chiton* Green, 1908 [Hemiptera: Coccidae]**

Synonyms and changes in combination: *Ceroplastodes chiton* Green (nomen nudum); *Ceroplastodes chiton* Green.

Common name(s): Longan soft scale.

Host(s): *Aleurites moluccana* (candlenut tree) (Ben-Dov *et al*., 2001); *Annona muricata* (soursop) (Ben-Dov *et al*., 2001); *Averrhoa carambola* (carambola) (Ibrahim, 1994); *Bauhinia* sp. (Ben-Dov *et al*., 2001); *Cajanus cajan* (pigeon pea) (Ben-Dov *et al*., 2001); *Calophyllum inophyllum* (Indian laurel) (Ben-Dov *et al*., 2001); *Camellia sinensis* (tea) (Das, 1969); *Canavalia* sp. (Ben-Dov *et al*., 2001); *Carica papaya* (papaya) (Ben-Dov *et al*., 2001); *Citrus aurantifolia* (lime) (Ben-Dov *et al*., 2001); *Colubrina* sp. (Ben-Dov *et al*., 2001); *Dalbergia* sp. (Ben-Dov *et al*., 2001); *Dimocarpus longan* (longan) (DOA, 2003); *Ficus microcarpa* (curtain fig) (Ben-Dov *et al*., 2001); *Ficus* sp. (fig) (Ben-Dov *et al*., 2001); *Gliricidia sepium* (Nicaraguan cocoashade) (Ben-Dov *et al*., 2001); *Grevillea papuana* (Ben-Dov *et al*., 2001); *Litsea* sp. (Ben-Dov *et al*., 2001); *Psidium guajava* (guava) (Mani, 1995; Mani and Krishnamoorthy, 1997); *Solanum melongena* (aubergine, eggplant) (Ben-Dov *et al*., 2001); *Theobroma cacao* (cocoa) (Ben-Dov *et al*., 2001); *Ziziphus mauritiana* (ber, Indian jujube) (Mani, 1995; Mani and Krishnamoorthy, 1997).

Plant part(s) affected: *Drepanococcus chiton* causes drying of shoots and flower stalks in carambola (Ibrahim, 1994).

Distribution: China (Ben-Dov *et al*., 2001); India (Andaman Islands, Himachal Pradesh, West Bengal) (Ben-Dov *et al*., 2001; Mani, 1995); Indonesia (Java) (Ibrahim, 1994); Malaysia (Ibrahim, 1994); Papua New Guinea (Ben-Dov *et al*., 2001); Solomon Islands (Ben-Dov *et al*., 2001); Sri Lanka (Ben-Dov *et al*., 2001); Taiwan (Ben-Dov *et al*., 2001); Thailand (DOA, 2003); Vietnam (Ben-Dov *et al*., 2001).

Biology: There is limited published information on the biology of *Drepanococcus chiton*.

In the Coccidae, the upper body is usually tough, or protected with a thick, hardened wax-like or mealy secretion (Smith *et al*., 1997). The female generally has four developmental stages, while the male has five (Williams, 1997). The first instar (or crawler) is the dispersal stage and is generally the most active developmental stage in soft scales (Williams, 1997). They become sessile for the remaining nymphal instars. Adult females are wingless, and sluggish or totally immobile (Smith *et al*., 1997). Adult males are delicate and short-lived (Smith *et al*., 1997). They are mobile, with one pair of wings. Adults of *D. chiton* have a glassy or resinous covering (Das, 1969).

Soft scales damage the host plant by sucking nutrients from plant parts, and excreting large amounts of sugary honeydew onto fruit and leaves, leading to sooty mould growth (Fasulo and Brooks, 1997; Smith *et al*., 1997).

Under laboratory conditions, the development of *D. chiton* eggs to adult maturity at 28°C was about 50 days (Ibrahim, 1994). On average, a female can produce about 1200 eggs with 97.9% viability (Ibrahim, 1994). However, only 2.5% of these eggs reached adult maturity in the field (Ibrahim, 1994).

Control: *Eunotus* sp. are egg parasitoids of *D. chiton* in carambola fields in Malaysia

(Ibrahim, 1994). The parasitoid was capable of destroying 93.2% of the eggs during larval development.

Parasitoids of *D. chiton* include the encyrtids *Anicetus ceylonensis*, *Diversinervus elegans*, *Metaphycus* sp. nr *helvolus* and *Philosindia* sp. nr *longicornis*; the pteromalid *Cephaleta brunniventris* and the coccinellids *Chilocorus nigrita*, *Cryptolaemus montrouzieri*, *Menochilus sexmaculata* and *Scymnus* sp. Only on guava did *Chilocorus nigrita* exert some influence on *D. chiton*. Otherwise, the parasitoids *A. ceylonensis* and *C. brunniventris* were responsible for suppressing *D. chiton* populations on ber and guava in India (Mani, 1995; Mani and Krishnamoorthy, 1997).

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***Pulvinaria psidii* Maskell, 1893 [Hemiptera: Coccidae]**

Synonyms and change in combination: *Pulvinaria cupaniae* Cockerell; *Pulvinaria psidii philippina* Cockerell; *Pulvinaria darwiniensis* Froggatt; *Lecanium vacuolatum* Dash (nomen nudum); *Pulvinaria cussoniae* Hall; *Pulvinaria gymnosporiae* Hall; *Chloropulvinaria psidii* (Maskell).

Common name(s): Green shield scale; guava mealy scale; guava scale; mango scale.

Hosts: *Alpinia purpurata* (red ginger) (Ben-Dov *et al*., 2001); *Alstonia scholaris* (devil tree) (Ben-Dov *et al*., 2001); *Alternanthera versicolor* (Ben-Dov *et al*., 2001); *Annona* sp. (custard apple) (Ben-Dov *et al*., 2001); *Anthurium* sp. (flamingo flower) (CABI, 2002); *Antidesma bunius* (Chinese laurel) (Ben-Dov *et al*., 2001); *Antigonon leptopus* (coral-vine) (Ben-Dov *et al*., 2001); *Artocarpus heterophyllus* (jackfruit) (Ben-Dov *et al*., 2001); *Asplenium nidus* (bird's nest fern) (Ben-Dov *et al*., 2001); *Barringtonia* sp. (Ben-Dov *et al*., 2001); *Bidens pilosa* (Spanish needles) (Ben-Dov *et al*., 2001); *Bignonia* sp. (cross-vine, trumpet flower) (Ben-Dov *et al*., 2001); *Bischofia javanica* (toog) (Ben-Dov *et al*., 2001); *Blighia sapida* (akee) (Ben-Dov *et al*., 2001); *Boronia serrulata* (scented boronia) (Ben-Dov *et al*., 2001); *Bouvardia* sp. (Ben-Dov *et al*., 2001); *Bryophyllum* sp. (Ben-Dov *et al*., 2001); *Cajanus cajan* (Congo pea, pigeon pea) (CABI, 2002); *Callistemon* sp. (bottlebrush) (Ben-Dov *et al*., 2001); *Camellia sinensis* (tea) (Ben-Dov *et al*., 2001; CABI, 2002); *Camellia* sp. (Ben-Dov *et al*., 2001; CABI, 2002); *Canna indica* (Indian shot) (Ben-Dov *et al*., 2001); *Capsicum annuum* (capsicum, bell pepper) (Ben-Dov *et al*., 2001); *Capsicum frutescens* (chilli pepper) (Ben-Dov *et al*., 2001); *Carissa carandas* (karanda) (Ben-Dov *et al*., 2001); *Chenopodium pumilio* (Tasmanian goosefoot) (Ben-Dov *et al*., 2001); *Chrysanthemum indicum* (Ben-Dov *et al*., 2001); *Chrysophyllum cainito* (star-apple) (Ben-Dov *et al*., 2001); *Chrysophyllum oliviforme* (damson plum, satinleaf) (Ben-Dov *et al*., 2001); *Cibotium* sp. (Ben-Dov *et al*., 2001); *Cinchona* sp. (Ben-Dov *et al*., 2001); *Citrus aurantifolia* (lime) (Ben-Dov *et al*., 2001); *Citrus aurantium* (Seville orange) (Ben-Dov *et al*., 2001); *Citrus limon* (lemon) (Ben-Dov *et al*., 2001); *Citrus sinensis* (navel orange) (Ben-Dov *et al*., 2001); *Citrus* spp. (CABI, 2002); *Clerodendrum* sp. (fragrant clerodendron) (Ben-Dov *et al*., 2001); *Clusia rosea* (balsam apple) (Ben-Dov *et al*., 2001); *Cocos nucifera* (coconut) (CABI, 2002); *Codiaeum* sp. (croton) (Ben-Dov *et al*., 2001); *Coffea arabica* (arabica coffee) (Ben-Dov *et al*., 2001); *Coffea canephora* (robusta coffee) (Ben-Dov *et al*., 2001); *Coffea liberica* (liberica coffee) (Ben-Dov *et al*., 2001); *Coffea* spp. (coffee) (CABI, 2002); *Colocasia esculenta* (taro) (Ben-Dov *et al*., 2001); *Comocladia* sp. (maiden plum) (Ben-Dov *et al*., 2001); *Cordia alliodora* (Spanish elm) (Ben-Dov *et al*., 2001); *Cordyline fruticosa* (good-luck plant) (Ben-Dov *et al*., 2001); *Cordia myxa* (Sudan teak) (Ben-Dov *et al*., 2001); *Crinum moorei* (bush lily) (Ben-Dov *et al*., 2001); *Cussonia arborea* (Ben-Dov *et al*., 2001); *Dahlia pinnata* (pinnate dahlia) (Ben-Dov *et al*., 2001); *Dianthus* sp. (carnation, pink) (Ben-Dov *et al*., 2001); *Dimocarpus longan* (longan) (Ben-Dov *et al*., 2001); *Diospyros kaki* (Japanese persimmon) (Ben-Dov

et al., 2001); *Diploknema butyracea* (Indian-buttertree) (Ben-Dov *et al*., 2001); *Dodonaea triquetra* (common hopbush) (Ben-Dov *et al*., 2001); *Duranta* sp. (Ben-Dov *et al*., 2001); *Elettaria cardamomum* (cardamom) (Ben-Dov *et al*., 2001); *Eriobotrya japonica* (loquat) (Ben-Dov *et al*., 2001); *Eucalyptus deglupta* (Mindanao gum) (Ben-Dov *et al*., 2001); *Euonymus* sp. (spindle tree) (CABI, 2002); *Eupatorium* sp. (Ben-Dov *et al*., 2001); *Euphorbia* sp. (spurge) (Ben-Dov *et al*., 2001); *Ficus benghalensis* (banyan tree) (Ben-Dov *et al*., 2001); *Ficus benjamina* (Benjamin-tree) (Ben-Dov *et al*., 2001); *Ficus elastica* (Indian rubber tree) (Ben-Dov *et al*., 2001); *Ficus macrophylla* (Moreton Bay fig) (Ben-Dov *et al*., 2001); *Ficus microcarpa* (curtain fig) (Ben-Dov *et al*., 2001); *Ficus religiosa* (bo tree) (Ben-Dov *et al*., 2001); *Ficus rubiginosa* (Port Jackson fig) (Ben-Dov *et al*., 2001); *Ficus sur* (cape fig) (Ben-Dov *et al*., 2001); *Ficus thonningii* (Ben-Dov *et al*., 2001); *Ficus* spp. (fig) (CABI, 2002); *Garcinia mangostana* (mangosteen) (Ben-Dov *et al*., 2001); *Gardenia jasminoides* (Cape jasmine) (Ben-Dov *et al*., 2001); *Gerbera* sp. (Ben-Dov *et al*., 2001); *Hedera helix* (common ivy) (Ben-Dov *et al*., 2001); *Hedychium* sp. (ginger lily) (Ben-Dov *et al*., 2001); *Heliconia bihai* (firebird) (Ben-Dov *et al*., 2001); *Hibiscus rosa-sinensis* (Chinese hibiscus) (Ben-Dov *et al*., 2001); *Hibiscus syriacus* (rose of Sharon) (Ben-Dov *et al*., 2001); *Ilex* sp. (holly) (CABI, 2002); *Ixora coccinea* (jungle geranium) (Ben-Dov *et al*., 2001); *Ixora macrothyrsa* (Ben-Dov *et al*., 2001); *Jasminum* sp. (jasmine) (Ben-Dov *et al*., 2001; CABI, 2002); *Kalanchoe* sp. (Ben-Dov *et al*., 2001); *Lagerstroemia indica* (crape myrtle) (Ben-Dov *et al*., 2001); *Lasianthus lanceolatus* (Ben-Dov *et al*., 2001); *Laurus* sp. (laurel) (Ben-Dov *et al*., 2001); *Litchi chinensis* (lychee) (Ben-Dov *et al*., 2001; CABI, 2002); *Livistona chinensis* (Chinese fan palm) (Ben-Dov *et al*., 2001); *Lycopersicum esculentum* (tomato) (Ben-Dov *et al*., 2001); *Macadamia* sp. (CABI, 2002); *Macaranga* sp. (Ben-Dov *et al*., 2001); *Mallotus philippinensis* (kamala) (Ben-Dov *et al*., 2001); *Malvaviscus arboreus* (wax mallow) (Ben-Dov *et al*., 2001); *Manilkara zapota* (sapodilla) (Ben-Dov *et al*., 2001; CABI, 2002); *Mangifera indica* (mango) (Ben-Dov *et al*., 2001; CABI, 2002); *Metrosideros* sp. (Ben-Dov *et al*., 2001); *Monstera deliciosa* (Swiss cheese plant) (Ben-Dov *et al*., 2001); *Morinda citrifolia* (Indian mulberry) (Ben-Dov *et al*., 2001); *Morus alba* (white mulberry) (Ben-Dov *et al*., 2001); *Myrtus communis* (true myrtle) (Ben-Dov *et al*., 2001); *Nerium oleander* (oleander) (CABI, 2002); *Pandanus* sp. (screwpine) (Ben-Dov *et al*., 2001); *Pelargonium* sp. (geranium) (Ben-Dov *et al*., 2001); *Persea americana* (avocado) (CABI, 2002); *Persea* sp. (CABI, 2002); *Phaeomeria* sp. (Ben-Dov *et al*., 2001); *Phlox* sp. (Ben-Dov *et al*., 2001); *Photinia serratifolia* (Chinese hawthorn) (Ben-Dov *et al*., 2001); *Pinus caribaea* (Caribbean pine) (Ben-Dov *et al*., 2001); *Piper methysticum* (kava kava) (Ben-Dov *et al*., 2001); *Pistacia atlantica* (Mt Atlas mastic tree) (Ben-Dov *et al*., 2001); *Pittosporum tobira* (Japanese mock orange) (Ben-Dov *et al*., 2001); *Plumeria rubra* f. *acutifolia* (Mexican frangipani) (Ben-Dov *et al*., 2001); *Plumeria rubra* (frangipani, red-jasmine) (Ben-Dov *et al*., 2001); *Pometia pinnata* (Pacific lychee, Pacific maple, taun) (Ben-Dov *et al*., 2001); *Poncirus trifoliata* (trifoliate orange) (Ben-Dov *et al*., 2001); *Prunus cerasifera* (cherry plum) (Ben-Dov *et al*., 2001); *Psidium guajava* (guava) (Ben-Dov *et al*., 2001); *Psidium*

sp. (guava) (CABI, 2002); *Psychotria rubra* (Ben-Dov *et al*., 2001); *Pteralyxia macrocarpa* (kaulu) (Ben-Dov *et al*., 2001); *Pteridium* sp. (bracken) (Ben-Dov *et al*., 2001); *Punica granatum* (pomegranate) (Ben-Dov *et al*., 2001); *Russelia* sp. (Ben-Dov *et al*., 2001); *Sanchezia* sp. (Ben-Dov *et al*., 2001); *Scaevola gaudichaudiana* (mountain naupaka) (Ben-Dov *et al*., 2001); *Schefflera actinophylla* (Australian umbrella tree) (Ben-Dov *et al*., 2001); *Schefflera* sp. (Ben-Dov *et al*., 2001); *Schinus molle* (California pepper tree) (Ben-Dov *et al*., 2001); *Schinus terebinthifolius* (Brazilian pepper tree) (Ben-Dov *et al*., 2001); *Sedum* sp. (stonecrop) (Ben-Dov *et al*., 2001); *Spondias dulcis* (golden-apple) (Ben-Dov *et al*., 2001); *Stachytarpheta* sp. (false vervain, snake-weed) (Ben-Dov *et al*., 2001); *Syzygium aromaticum* (clove) (Ben-Dov *et al*., 2001); *Syzygium cumini* (jambolan) (Ben-Dov *et al*., 2001); *Syzygium jambos* (rose apple) (Ben-Dov *et al*., 2001); *Syzygium malaccense* (Malay apple) (Ben-Dov *et al*., 2001); *Syzygium* spp. (brush cherry, lillypilly) (CABI, 2002); *Tamarix gallica* (French tamarisk) (Ben-Dov *et al*., 2001); *Tamarix* sp. (tamarisk) (CABI, 2002); *Tarenna sambucina* (Ben-Dov *et al*., 2001); *Tecoma stans* (yellow trumpet flower) (Ben-Dov *et al*., 2001); *Tecomaria* sp. (Ben-Dov *et al*., 2001); *Terminalia brassii* (brown terminalia) (Ben-Dov *et al*., 2001); *Terminalia* sp. (tropical almond) (CABI, 2002); *Tetrapanax papyrifer* (Chinese rice-paper plant) (Ben-Dov *et al*., 2001); *Thespesia populnea* (portia tree) (Ben-Dov *et al*., 2001); *Toxicodendron* sp. (Ben-Dov *et al*., 2001); *Uapaca kirkiana* (wild loquat) (Ben-Dov *et al*., 2001); *Vanilla* sp. (Ben-Dov *et al*., 2001); *Wollastonia biflora* (Ben-Dov *et al*., 2001); *Zantedeschia aethiopica* (white arum lily) Ben-Dov *et al*., 2001); *Zingiber officinale* (ginger) (Ben-Dov *et al*., 2001).

Plant part(s) affected: Fruit (Waite and Hwang, 2002); leaves and twigs of longan and lychees (Waite and Hwang, 2002). The pest may be present on the fruit if flowering panicles are infested, causing sooty mould formation (CABI, 2002; Waite and Elder, 1999; Waite and Hwang, 2002).

Distribution: Afghanistan, Algeria, Angola, Antigua and Barbuda (Antigua), Australia (Australian Capital Territory, New South Wales, Northern Territory, Queensland) (AgWA (2003) states that it is not present in Western Australia), Bahamas, Bangladesh, Barbados, Bermuda, Bhutan, Brazil, Brunei, Cambodia, Cape Verde, China (Hong Kong, Hubei, Hunan), Congo, Cook Islands, Costa Rica, Côte d'Ivoire, Cuba, Dominican Republic, Egypt, Micronesia, Federated States of (Caroline Islands, Ponape Island, Truk Islands), Fiji, French Polynesia (Tahiti), Ghana, Grenada, Guadeloupe, Guatemala, Guyana, India, Indonesia (Irian Jaya), Israel, Jamaica, Japan (Bonin Islands, Ryukyu Islands), Kiribati, Kenya, Madagascar, Malawi, Malaysia (Sabah, Sarawak), Marshall Islands, Martinique, Mauritius, Mexico, Mozambique, Nepal, New Caledonia, New Zealand, Nigeria, Niue, Northern Mariana Islands, Palau, Papua New Guinea (New Britain), Philippines, Ponape Island, Puerto Rico, Réunion, Saint Helena (Ascension Island), Saint Kitts and Nevis, Saint Vincent and the Grenadines, Senegal, Seychelles (Aldabra Island, Farquhar Island, Providence Island), Singapore, Solomon Islands, South Africa, Spain (Canary Islands), Sri

Lanka, Sudan, Sumatra, Taiwan, Tanzania, Thailand, Tonga, Trinidad and Tobago, Tunisia, Uganda, United Kingdom (England), United States (Alabama, Florida, Georgia, Hawaii, Mississippi, Missouri, New York, Pennsylvania), Vanuatu, Venezuela, Western Samoa, Zaire, Zimbabwe (Ben-Dov *et al*., 2001).

Biology: *Pulvinaria psidii* reproduces by parthenogenesis and males are unknown (CABI, 2002). First instar nymphs (or crawlers) are 0.35 mm long. The two intermediate immature instars are greenish brown, sometimes translucent, flat and oval, lacking any sign of wing pads, with two black eyes. Adult females are ovoid and moderately convex in shape, 2.5-4.5 mm long and 2-3 mm wide, deep green to yellowish in colour with dark eyespots near the margin of the head. The limbs are short and hidden beneath the body. Once the female begins to oviposit, a conspicuous white cottony wax ovisac up to 6.5 mm long is secreted from under the posterior end of the abdomen and becomes attached to the substrate (CABI, 2002). Eventually, the cottony secretion almost surrounds the scale, which darkens, shrinks and becomes concertinaed with age (Bartlett, 1978; Hamon and Williams, 1984).

In the laboratory, *P. psidii* have been reared on pumpkin fruits. Females laid about 200 eggs, which took 11-28 days to hatch. On hatching, the first instar walks about actively to locate a feeding site. The life cycle lasted 180-210 days (El-Mishawy and Moursi, 1976). In Egypt there are two generations per year (Swirsky *et al*., 1997a), while three generations per year have been recorded in Taiwan. In Sri Lanka, the generations overlap on ornamental and house plants (Kosztarab, 1997).

Observations on an Egyptian guava orchard by Salama and Saleh (1970) suggest that *P. psidii* thrives best at temperatures of 26-27.3°C and a relative humidity of about 72%, and avoids excessively hot situations and both very bright light or deep shade. Most tropical soft scale species suffer increasing mortality over 29°C.

Colonies of *P. psidii* extract large quantities of sap, causing general host debilitation and build-up of sticky honeydew deposits on nearby surfaces. Sooty moulds can grow on the sugary deposits. Badly fouled leaves may be dropped prematurely and the quality of fruits may be reduced in, for example, guava (Swirski *et al*., 1997a). Honeydew production is greatest during periods of rapid growth and oviposition. Ants may be attracted to colonies by the honeydew excreted and may deter natural enemies from attacking the scales (Monaco and D'Abbicco, 1987; Williams and Watson, 1990).

The main dispersal stage for mealybugs is the first instar or crawler. Dispersal by crawlers is limited to one plant or adjacent plants if they are touching. However, crawlers can be carried between plants and sites by wind or on larger animals including man, and all life cycle stages can be transported on ornamental plants, propagation material or produce (CABI, 2002). Heavy rain causes very high crawler mortality and very high humidity often favours entomopathogenic fungal attack.

Control: The effectiveness of insecticide applications against soft scales may be reduced

by the waxy coating of the adult. Applications may be more effective if directed at the younger stages (Crowe, 1962). In Egypt, sprays of oils and insecticides have been used against *P. psidii*, and were more effective in summer than in winter. Organophosphorous insecticides like pirimiphos-methyl, formothion and malathion were more effective than the oil sprays (Nada *et al*., 1990).

Ants attracted to the honeydew produced by *P. psidii* may deter natural enemies from attacking the scales; therefore the first step in a biological control programme should be to control any attendant ants (Annecke and Moran, 1982).

Parasitoids of *P. psidii* include: *Aphycus stanleyi* and *Argutencyrtus luteolus* attacking nymphs and adults in South Africa; *Bothriophryne pulvinariae* attacking nymphs and adults in India; *Bothriophryne tenuicornis* attacking nymphs and adults in Egypt and India; *Coccophagus bogoriensis* attacking nymphs and adults in India and Indonesia; *Coccophagus cowperi* attacking nymphs and adults in South Asia and Africa; and *Microterys nietneri* attacking nymphs and adults in the USA and Hawaii (CABI, 2002).

Predators of *P. psidii* include: *Cheilomenes sexmaculata* and *Chilocorus nigrita* attacking nymphs and adults in South Asia; *Cryptolaemus montrouzieri* attacking nymphs and adults in Bermuda; and *Pseudazya orbigera* attacking nymphs and adults (CABI, 2002).

Pathogens of *P. psidii* include *Fusarium oxysporum* and *Verticillium lecanii* which attack nymphs and adults in India (CABI, 2002).

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Stink bugs

***Nezara antennata* Scott [Hemiptera: Pentatomidae]**

Synonyms and changes in combination: None.

Common name(s): Common green stink bug; far eastern green stink bug; green stink bug; Oriental green stink bug.

Host(s): *Nezara antennata* is a polyphagous pest, attacking approximately 80 plant species in 25 families (Panizzi *et al*., 2000). Hosts include: *Abelmoschus esculentus* (okra) (Yanagisawa and Hara, 1994); *Asparagus officinalis* (asparagus) (Hsu and Hsu, 1977); *Dimocarpus longan* (longan) (AQSIQ, 2003; Tan *et al*., 1998); *Glycine max* (soybean) (Mizutani, 2001); *Litchi chinensis* (lychee) (AQSIQ, 2003; Tan *et al*., 1998), *Malus fusca* (Oregon crab apple) (Li *et al*., 2001); *Oryza sativa* (rice) (Yokoyama *et al*., 1972); *Vigna mungo* (black gram) (Gyawali, 1989).

Plant part(s) affected: Young fruit, leaves and shoots (AQSIQ, 2003; Li *et al*., 2001). Tan *et al*. (1998) reported that *N. antennata* damages fruits and tender leaves of longan and lychee plants. This species also damages the seeds (Kobayashi, 1972) and pods (Kawamoto *et al*., 1987) of soybean plants in Japan.

Distribution: China (Li *et al*., 2001; Tan *et al*., 1998); India (Azim and Shafee, 1978); Japan (Kawamoto *et al*., 1987; Kobayashi, 1976; Mizutani, 2001); Nepal (Gyawali, 1989); Korea, Republic of (Jang and Choe, 1992).

Biology: Adults are about 15 mm long and green to blue/green in colour (Anon., 2003).

This species has 2-3 generations per year with adults overwintering (Panizzi *et al*., 2000). The following spring, females begin ovipositing when the maximum temperature reaches 14-15°C (Panizzi *et al*., 2000), and adults of the first generation appear from late June to the middle of September. Oviposition is accelerated by short photoperiods (Noda, 1984). Under long-day conditions (photoperiods of 16 hours or more), the preoviposition period lasted 42-45 days and that under relatively short-day conditions (photoperiods of less than 16 hours), it averaged less than 23 days. A facultative adult diapause was observed when nymphs had been exposed to photoperiods of 14 hours or less (Noda, 1984).

On a soybean diet under laboratory conditions, the nymphal period is 27 days and the pre-oviposition period of adult females is up to 80 days (Kadosawa and Santa, 1981). *N. antennata* shows a preference for indeterminate varieties of soybean in South Korea (Son *et al*., 2000). In laboratory studies in Japan, the feeding behaviour of *N. antennata* on soybean pods was studied. Where smaller beans were concerned, the pest preferentially fed on undamaged beans whereas where larger beans were concerned, the level of bean damage did not affect the pest's choice (Kawamoto *et al*., 1987). In field experiments on 40 soybean varieties in Japan, it was found that the later-flowering varieties are least

damaged by *N. antennata* and two other bugs (Kobayashi *et al*., 1972). Damage to apples in China by this species appears as a red/brown gum-like secretion around the hole where the pest entered the fruit. This causes deformation, which leads to loss of eating quality. The most damage is done by nymphs from mid to late April (Li *et al*., 2001).

Control: Studies carried out on apple trees in China in late March to early April, in mid-late April and in early-mid May showed that spraying a 1500-200 times solution of 30% Taoxiaoling, of unstated composition, or a 2000-3000 times solution of 20% Sumicidin (fenvalerate) gave good chemical control of *N. antennata* (Li *et al*., 2001).

The hymenopteran *Ooencyrtus nezarae* Ishii is an egg parasitoid of *N. antennata* in soybean fields (Mizutani, 2001).

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***Tessaratoma papillosa* (Drury) [Hemiptera: Tessaratomidae]**

Synonyms and changes in combination: *Cimex papillosa*.

Common name(s): Litchi stink bug; longan stink bug; lychee stink bug.

Host(s): Liu (1965) reported that *T. papillosa* fed on 21 species of plants, but primarily on *Litchi chinensis* (litchi) and *Dimocarpus longan* (longan). Other hosts include: *Citrus* sp. (CABI, 2002; Chen, 1984); *Musa* sp. (banana, plantain) (Chen, 1984); *Olea europaea*

(olive) (Chen, 1984); *Prunus domestica* (plum, prune) (CABI, 2002; Chen, 1984); *Prunus persica* (peach) (CABI, 2002; Chen, 1984); *Pyrus communis* (European pear) (CABI, 2002; Chen, 1984).

Plant part(s) affected: Fruit, inflorescence, stem (CABI, 2002). AQSIQ (2003) reported that *T. papillosa* affects the fruits, stems and leaves of longan and lychee plants. The pest also affects the flowers of longan and lychee plants (Waite and Hwang, 2002).

Distribution: China (Fujian, Guangdong, Guangxi, Guizhou, Jiangxi, Yunnan), India, Indonesia, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam (CABI, 2002).

Biology: In China, *T. papillosa* has one generation per year. Adults tend to aggregate and overwinter (hibernate) mostly on lychee and longan, but may also be found on other hosts in warm protected areas. In spring, the females are attracted to trees with new flowers and shoots (Waite and Hwang 2002). Females mate more than twice, and mating takes a long time. Egg laying occurs 1-2 days after mating (CABI, 2002). Females lay up to 14 egg masses, each containing about 14 eggs, on the back of leaves of longan and lychee (Menzel, 2002). The eggs are laid in a batch and held together by secretions. Each female lays 5-10 times in its lifetime (CABI, 2002). Eggs are approximately round and 2.5-2.7 mm long. Freshly laid eggs are light green to yellow and they gradually become yellow-brown over time. Eggs close to hatching are dark grey. Peak egg-laying occurs in March in Guangdong, but continues through to September.

T. papillosa has five nymphal instars. The first-instar nymphs are elliptical and about 5 mm long. They have a fresh-red, later dark-blue body colour. The nymphs have deep-red compound eyes and a pair of stink glands lies in the dorsal abdomen, between the fourth and fifth, and fifth and sixth segment. The first nymphs mature in June, while there are still old adults in the trees. These old adults may have lived for up to a year, and generally die by August. Second-instar nymphs become rectangular in shape and are about 8 mm long. They are orange-red with a dark-grey colour along the margin. The centre of the abdominal dorsal terminal has two dark-grey stripes extending to the anterior position, and there are two yellow spots in each segment the stripe passes along. The third-instar nymphs are 10-12 mm long and are similar in form and colour to second-instar nymphs. The fourth-instar nymphs are 14-16 mm long and similar to the third-instar nymphs in form and body colour. Fifth-instar nymphs are 18-20 mm long and similar in form to the fourth-instar nymphs, although they are lighter in colour.

Adults are yellow-brown and shield-like in shape. The females are 24-28 mm long and 15-17 mm wide, and are larger than the males. Huang *et al*. (1984) provides descriptions and identification keys for *Tessaratoma* spp. The new adults do not mate immediately, but mature over winter and mate and lay eggs the following spring (Waite and Hwang, 2002). In China, nymphs and adults of *T. papillosa* suck the sap of the flowering and fruiting

shoots during April and June (Falkenstein, 1925), causing flowers and fruits to fall, the necrosis of young twigs and the blackening of fruit exocarp (CABI, 2002). They also feed on terminals, which may be killed (Zhang, 1997). Nymphs are able to survive periods of up to 12 days without feeding (Waite and Hwang, 2002). The adults live for up to 311 days (CABI, 2002).

T. papillosa is a major pest of litchi and longan in South China and infestation normally reduces the fruit yield by 20-30%, and may reduce it by 80-90% if the infestation is heavy (CABI, 2002). Field infestations are detected by surveying the backs of leaves of litchi trees for egg batches. Liu and Lai (1998) reported that up to 30% of fruit in commercial orchards are damaged despite chemical applications. Liu (1965) gives detailed information on the reduction in litchi and longan yield in Dongguan county, Guangdong Province in South China.

Control: One method of chemically controlling *T. papillosa* involves two applications of trichlorfon, one to kill the overwintered adults and the other to kill the young nymphs as they hatch from the eggs. The tolerance of *T. papillosa* to insecticides is reduced after hibernation before the adults begin to lay and just after egg hatching, so these are the best times to apply chemical control (CABI, 2002). Lin and Chiu (1983) used the chemosterilant sulfotep to treat *T. papillosa* males. The treated males were released onto litchi trees in the field. This resulted in 94.4% of unhatched eggs. If the males were treated with both sulfotep and bisazir, 96.5% of the eggs failed to hatch. Importantly, the parasitoid *Ooencyrtus* sp. was not affected by the treatment.

In Guangdong Province in China, the main natural enemies are the egg parasitoids, *Encyrtus* (*Ooencyrtus*) sp., *Anastatus* sp. and *Blastophaga* sp. which parasitise 70 to 90% of eggs laid late in the season. Similar results were recorded by Liu and Lai (1998) when parasitised egg cards were hung in trees during March. In orchards under integrated pest management, combined parasitism rates by *Anastatus* sp. and *Ooencyrtus* sp. may reach 50% in June, but may be less than 3% in orchards that rely on chemicals.

During the 1970s, biological control in Guangdong was initiated using the egg parasitoid *Anastatus japonicus* Ashmead, the flat venter wasp, after field trials had demonstrated its value. Since only 10% of eggs are parasitised by April when most of the eggs are laid, natural control is ineffective. In contrast, very good control with up to 90% parasitism is achieved after mass release of wasps.

In Thailand, the egg parasitoids *Anastatus* sp. nr *japonicus* and *Ooencyrtus phongi*, operate in a similar manner to their counterparts in China. Low levels of control are achieved during the critical early fruit production period, building up to good levels later (Waite and Hwang, 2002). Mass rearing of the parasitoids in the wild silk worm, *Philosamia ricini* Hutt. and releasing them early, produced results similar to those in China. *Anastatus* sp. and *O. phongi* parasitised 79% and 21% of eggs, respectively (Nanta, 1992).

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Lycaenid fruit borer

***Deudorix epijarbas* (Moore, 1858) [Lepidoptera: Lycaenidae]**

Synonyms and changes in combination: *Deudorix amatius* Fruhstorfer; *Deudorix ancus* Fruhstorfer; *Deudorix cinnabarus* Fruhstorfer, *Deudorix coriolanus* Fruhstorfer; *Deudorix diara* Swinhoe; *Deudorix epijarbas amatius* Fruhstorfer; *Deudorix epijarbas epijarbas* Moore; *Deudorix megakles* Fruhstorfer; *Deudorix menesicles* Fruhstorfer; *Deudorix mesarchus* Fruhstorfer; *Deudorix perbella* Murayama; *Rapala koshuna* Sonan.

Common name(s): Anar fruit butterfly; cornelian; dull cornelian; pomegranate butterfly; pomegranate fruit borer.

Host(s): *Aesculus indica* (Indian horse chestnut) (Rab, 1980); *Caryota albertii* (kulandoi) (Herbison-Evans and Crossley, 2002); *Connarus conchocarpus* (shell vine) (Herbison-Evans and Crossley, 2002); *Dimocarpus longan* (longan) (AQSIQ, 2003; DOA, 2003a; Tan *et al*., 1998); *Litchi chinensis* (lychee) (AQSIQ, 2003; DOA, 2003b; Tan *et al*., 1998), *Macadamia integrifolia* (macadamia nut) (Ironside, 1979); *Nephelium lappaceum* (rambutan) (CABI, 2002); *Punica granatum* (pomegranate) (CABI, 2002, Rab, 1980); *Salacia chinensis* (lolly berry vine) (Herbison-Evans and Crossley, 2002); *Salacia disepala* (Herbison-Evans and Crossley, 2002); *Sarcopteryx martyana* (scrub tamarind) (Herbison-Evans and Crossley, 2002)

Plant part(s) affected: Generally, *Deudorix epijarbas* feeds on the seeds within the fruit (Herbison-Evans and Crossley, 2002). This pest bores into the fruit of longan and lychee (DOA, 2003a, b; Tan *et al*., 1998). Occasionally this pest attacks young longan and lychee fruits and attacked fruits drop off prematurely (AQSIQ, 2003).

Distribution: Australia (Nielsen *et al*., 1996) but not in Western Australia (AgWA, 2003); China (Hainan, Hong Kong) (CIQ, 2000; Tan *et al*., 1998); Fiji (Herbison-Evans and Crossley, 2002); India (Andaman and Nicobar Islands) (Waite and Hwang, 2002); Indonesia (Kalshoven and van der Laan, 1981); Laos (Motono and Negishi, 1989); Philippines (Palawan) (Herbison-Evans and Crossley, 2002); Sri Lanka (Yutaka, 1999); Sulawesi (Yutaka, 1999); Taiwan (Yutaka, 1999); Thailand (DOA, 2003a; Waite and Hwang, 2002); Vietnam (Metaye, 1957).

Biology: Eggs of *Deudorix epijarbas* are bright blue in colour (Rab, 1980). Caterpillars are green or brown with orange posterior ends, the head is brown with black spots (Herbison-Evans and Crossley, 2002). Adult males are brown on top with a large orange patch on each wing. Adult females are brown with a purple sheen. Both sexes have one long filamentous tail on each hind wing (Herbison-Evans and Crossley, 2002).

This species is recorded as a minor pest of longan and lychee in India (Waite and Hwang, 2002). Single eggs are laid on the fruit and the larva bores inside to destroy the flesh and

the seed (Waite and Hwang, 2002). The larvae are able to move from fruit to fruit damaging 3 or 4 in the process. A neat round hole is chewed in the skin of the fruit and the larvae plugs this with its flattened rear end, as it feeds inside. The larvae apparently produce a substance that attracts ants as these insects are often seen in attendance (Waite and Hwang, 2002).

Under laboratory conditions in India, pupae hibernated inside the conkers of pomegranate. The female laid eggs singly on the flowers and fruits of pomegranate (Verma, 1985). After hatching, the larvae bore into the fruit and feed on the immature seeds (Verma, 1985). The incubation period for the eggs was 5-8 days and for the larvae 15-24 days in April-July. The larva pupated either inside the fruit or outside on the stalk of the damaged fruit; the pupal period lasts 8-10 days. The lifespan of the adults was 1-5 days. There were 3-4 generations of the pest in a year on pomegranate, and adults migrated to horse chestnuts (Verma, 1985).

In India, *D. epijarbas* infested pomegranate with a mean fruit infestation of 25.33% (Thakur *et al*., 1995).

Control: In India, foliar applications of cypermethrin and permethrin, fenvalerate and deltamethrin provide effective chemical control of *D. epijarbas*. Also, two foliar sprays of fenvalerate, cypermethrin or deltamethrin in July, followed by a cover spray after 45 days, gives effective and profitable control of the pest (Kakar *et al*., 1987).

Parasitoids of *D. epijarbas* include: *Anastatus* sp. nr *kashmirensis* attacking eggs (Thakur *et al*., 1995); *Glyptapanteles vitripennis* attacking larvae (CABI, 2002); and *Telenomus cyrus* and *Trichogramma chilonis* attacking eggs (CABI, 2002; Thakur *et al*., 1991).

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Litchi fruit borer

***Conopomorpha sinensis* Bradley [Lepidoptera: Gracillariidae]**

Synonyms and changes in combination: None known.

Common name(s): Lychee fruit borer; lychee stem-end borer.

Host(s): *Dimocarpus longan* (longan), *Litchi chinensis* (lychee) (He, 2001; Hwang and Hung, 1996; Waite and Hwang, 2002).

Plant part(s) affected: Larvae penetrate and feed on longan and lychee fruit (Waite and Hwang, 2002). Adults feed externally on the fruit (He, 2001; Waite and Hwang, 2002). *C. sinensis* preferentially attacks lychees over longans. In both crops, damaged fruit often falls from the tree (Waite and Hwang, 2002).

Distribution: China (Waite and Hwang, 2002); India (Waite and Hwang, 2002); Taiwan (Hwang and Hung, 1996); Thailand (Schuetz *et al*., 2002; Waite and Hwang, 2002).

Biology: *Conopomorpha sinensis* lays yellow, scale-like eggs that are 0.4 mm long by 0.2 mm wide on longan and lychee fruit as well as on new leaves and shoots in China, Taiwan and Thailand. They prefer orchards with shady, humid and closed conditions (Zhang *et al*., 1997). The eggs hatch in 3-5 days, with the larva immediately penetrating the fruit, leaf or shoot (Waite and Hwang, 2002). One or more eggs may be laid on a fruit but generally only one larvae per fruit survives (Waite and Hwang, 2002). Larvae tunnel through the flesh of the fruit, which often falls from the tree as a result of the damage they sustain (Waite and Hwang, 2002). During the off-season, when fruit is not available, the larvae can survive by feeding on young leaves and shoots (Waite and Hwang, 2002).

Mature larvae are 6-10 mm long and brownish in colour or green if their diet has consisted predominantly of leaves. Pupation occurs 8-12 days later under mature leaves in crème coloured oval cocoons. An adult moth emerges 5-7 days later after it has changed from a brownish/light green to a dark brown colour. Adults are very small with long thin antennae and narrow fringed forewings that are 8-11 mm across when expanded. Adults feed

externally on longan and lychee fruit and their lifespan is from 5-8 days (Waite and Hwang, 2002). The moths are attracted to leaf flushes that emerge during the rainy season from June to October in Thailand (Menzel, 2000). Affected shoots often wilt.

In Taiwan, this pest can complete 4-5 generations during the longan and lychee season. In the Guangzhou district of China, there are 11 overlapping generations each year (Zhang *et al*., 1997). Under normal conditions in lychee orchards in Guangdong Province, the first generation of moths come in late March - early April; early May; late May, mid-late June and early-mid July for successive generations. However, this schedule can vary from year to year and from region to region (Zhang *et al*., 1997). The second, third and fourth generation of moths cause the most severe damage to lychee trees by laying eggs into the fruit.

Control: In Thailand, fruits are inspected weekly from fruit set to detect eggs of *C. sinensis*, which are very small and almost invisible to the naked eye. When the pest becomes more active, permethrin is applied weekly, up to two weeks before harvest. In Taiwan, cypermethrin, deltamethrin, carbofuran or fenthion during early fruit set is recommended to prevent damage later in the season. Moths can be excluded by enclosing the fruit panicles in nylon mesh bags, but this method is uneconomic in areas with high labour costs (Waite and Hwang, 2002).

In lychee orchards in southern China, the moths are best controlled at the second generation for early season varieties like ‘Sanyuehong’; the third for mid-season varieties such as ‘Heiya’ and ‘Feizixaiao’; and the fourth for late season varieties such as ‘Guiwei’, ‘Nuomici’ and ‘Huaizhi’; and even at the fifth and sixth generation of moths for very late seasons or varieties (Zhang *et al*., 1997). Recommended practise on lychee is to limit winter shoot sprouting to reduce overwintering, prune old, dead and shading branches to improve ventilation, and spray insecticides according to infestation forecasts. Pesticides include 40.7% lorsban (1:1000), 10% cypermethrin (1:20,000) or 25% shachongshuang (1:800) with 90% trichlorfon (1:800) sprayed at 30% emergence stage and repeated 5-7 days later (Zhang *et al*., 1997).

The following microhymenopterous parasitoids attack the larvae of *C. sinensis* in Thailand: *Phanerotoma* sp., *Colastes* sp., *Pholestesor* sp. and *Goryphus* sp., which may also attack the pupae (Waite and Hwang, 2002). In Taiwan, four species of hymenopterous parasitoids have been reported from a species similar to *C. sinensis*, *Conopomorpha cramerella*. Two of these (*Tetrastichus* sp. and *Elasmus* sp.) attack the larvae and two (*Phanerotoma* sp. and *Apanteles* sp.) attack the pupae (Hwang and Hsieh, 1989).

Pests present in fallen fruit may have been parasitised before or after the fruit fell from the tree. Therefore, it is recommended that all fallen fruit with parasitoids should be left under the trees so that parasitoid populations may increase. If the fruit does not contain parasitoids it is advisable to remove and destroy the fruit so that un-parasitised larvae do

not accumulate (Waite and Hwang, 2002).

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Leaf rollers

***Adoxophyes cyrtosema* Meyrick [Lepidoptera: Tortricidae]**

Synonyms and changes in combination: None.

Common name(s): Citrus brown-banded tortrix; citrus leafroller.

Host(s): *Dimocarpus longan* (longan) (Waite and Hwang, 2002); *Glyceria fluitans* (floating sweet grass) (Liu *et al*., 2001); *Litchi chinensis* (lychee) (Waite and Hwang, 2002).

Plant part(s) affected: Longan and lychee fruit, flower, leaf and new growth (Menzel, 2002).

Distribution: China (Liu *et al*., 2001) (Guangzhou, Fujian (Waite and Hwang, 2002)).

Biology: In Guangzhou Province China, *A. cyrtosema* has about nine generations per year (Waite and Hwang, 2002). The larvae overwinter in citrus nurseries or on grasses and pupate in March. Emerging moths then fly into lychee and citrus orchards where they mate and lay eggs on the leaves (Waite and Hwang, 2002). Female moths lay up to three egg masses, each with about 140 eggs (Waite and Hwang, 2002). They take an average of six days to hatch. The larvae web and roll leaves together to form a shelter in which they feed (Waite and Hwang, 2002). This species has been recorded feeding externally on longan and lychee fruit (Waite and Hwang, 2002).

The occurrence of *A. cyrtosema* on sweet grass in China was closely correlated with temperature, humidity, and precipitation (Liu *et al*., 2001). The infestation of the pest could be divided into four stages. The first stage was from early June to last July. The population of the insect tended to reduce at this stage. The second stage was in August and the larvae were in overwintering stage. The third stage was early September to early October and the population began to increase and reached peaks in mid-October and mid-November, each beginning to reduce from the end of November. The fourth stage was from early December to the next May and the population began to increase again and reached peaks once in early January, middle February, middle April, and the last 10 days of May (Liu *et al*., 2001).

Control: In China, *A. cyrtosema* is parasitised by *Trichogramma* sp., *Apanteles* sp., *Brachymeria obscurata*, *Phaeogenes* sp. and *Nemorilla floralis maculosa* as well as being predated by the beetle *Calleida* sp. and the fly *Xanthandvus comtus* (Waite and Hwang, 2002).

In laboratory tests, chlorpyrifos at various dilutions gave best control of this pest on sweet grass, with mortality of 100% 4 hours after application (Liu *et al*., 2001). In field trials, chlorpyrifos at various dilutions and abamectin at various dilutions all could effectively kill the larvae. Control effectiveness was still 100% at 48 hours after application (Liu *et al*., 2001).

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***Adoxophyes orana* (Fischer von Röeslerstamm, 1834) [Lepidoptera: Tortricidae]**

Synonyms and changes in combination: *Adoxophyes fasciata* Walsh; *Adoxophyes reticulana* Hübner; *Adoxophyes tripsiana*; *Cacoecia reticulana*; *Capua congruana*; *Capua orana*; *Capua reticulana* Hübner; *Tortrix orana* Fischer von Röeslerstamm; *Tortrix reticulana*.

Common name(s): Apple peel tortricid; smaller tea tortrix; summer fruit tortrix.

Host(s): *Acer campestre* (maple) (CABI, 2002); *Alnus* sp. (alder) (CABI, 2002); *Betula* sp. (birch) (CABI, 2002); *Carpinus betulus* (European hornbeam) (CABI, 2002); *Corylus* sp. (hazel) (Carter, 1984); *Crataegus* sp. (hawthorn) (CABI, 2002); *Cydonia oblonga* (quince) (CABI, 2002); *Dimocarpus longan* (longan) (Huang *et al*. 1997); *Fagus sylvatica* (beech) (CABI, 2002); *Forsythia suspensa* (weeping forsythia) (CABI, 2002); *Gossypium herbaceum* (Arabian cotton) (CABI, 2002); *Humulus* sp. (hop) (CABI, 2002); *Laburnum anagyroides* (common laburnum) (CABI, 2002); *Ligustrum* sp. (privet) (CABI, 2002); *Litchi chinensis* (lychee) (Huang *et al*. 1997); *Lonicera xylosteum* (fly honeysuckle) (CABI, 2002); *Malus baccata* (Chinese crab apple) (CABI, 2002); *Malus pumila* (paradise apple) (CABI, 2002); *Medicago* sp. (medic) (CABI, 2002); *Pistacia lentiscus* (mastic tree) (CABI, 2002); *Populus* sp. (poplar) (CABI, 2002); *Prunus armeniaca* (apricot) (CABI, 2002); *Prunus avium* (gean, wild cherry) (CABI, 2002); *Prunus domestica* (plum, prune) (CABI, 2002); *Prunus padus* (bird cherry) (CABI, 2002); *Prunus persica* (peach) (CABI, 2002); *Prunus triloba* (flowering almond tree) (CABI, 2002); *Pyrus communis* (European pear) (CABI, 2002); *Ribes nigrum* (blackcurrant) (CABI, 2002); *Ribes rubrum* (red

currant) (CABI, 2002); *Ribes uva-crispa* (gooseberry) (CABI, 2002); *Rosa canina* (dog rose) (CABI, 2002); *Rosa* sp. (rose) (CABI, 2002); *Rubus fruticosa* (blackberry) (CABI, 2002); *Rubus idaeus* (raspberry) (CABI, 2002); *Salix caprea* (pussy willow) (CABI, 2002); *Salix viminalis* (basket willow) (CABI, 2002); *Symphoricarpos albus* (snowberry) (CABI, 2002); *Syringa vulgaris* (lilac) (CABI, 2002); *Tilia* sp. (lime) (CABI, 2002); *Ulmus minor* (field elm) (CABI, 2002); *Vaccinium* sp. (blueberry) (CABI, 2002).

Plant part(s) affected: Fruit, leaf, inflorescence, growing points, shoot, trunk (CABI, 2002). *A. orana* is reported to affect young fruits, fresh leaves, tips and spikes of longan and lychee (Huang *et al*., 1997). Young fruits that are attacked are shed early and easily (AQSIQ, 2003).

Distribution: Armenia, Austria, Azerbaijan, Belgium, Bulgaria, China (Hebei, Hong Kong, Sichuan), Denmark, Finland, France, Georgia (Republic), Germany, Hungary, Italy, Japan (Hokkaido, Honshu, Kyushu, Shikoku), Netherlands, Norway, Poland, Romania, Russian Federation (Russian Far East, Siberia), Korea, Republic of, Spain, Sweden, Switzerland, Ukraine, United Kingdom (England, Wales), Yugoslavia (CABI, 2002).

Biology: Egg laying is initiated at 135 day-degrees above 10°C from the start of the flight period onwards (CABI, 2002). Eggs of *A. orana* are yellowish and deposited in egg masses often with 25-150 together (CABI, 2002). Oviposition takes place mostly in the late afternoon and evening. More than 300 eggs might be deposited per female (CABI, 2002). The eggs are laid on leaves, fruits and, for severe infestations, even on the tree trunk (CABI, 2002). Egg development stops at temperatures lower than 9°C (CABI, 2002). Shortly before hatching the black head-capsule of the larvae becomes visible. After hatching, which mostly occurs at 8-14 days after egg laying (de Jong, 1980; Soenen, 1947), the transparent egg shells remain visible.

Larvae are greenish with light hairs and warts. The head is light brown to yellow (sometimes spotted) as is the thoracic and anal shield. The thoracal legs are brown to black; while abdominal and anal legs are greenish. The head is as long as wide. The pupae are 8-11 mm long and initially light brown, but become dark brown towards the time of emergence of the adult moth. The posterior margin of abdomen segments 2 to 8 of the pupae contain very small bristles and are visible as a line.

The first larval stages make silken spinnings along the veins on the lower side of leaves (CABI, 2002). After some days, they start spreading and damaging the whole leaf surface and the shoot (CABI, 2002). Larvae develop quickly through the five larval stages. A full grown larvae reaches a length of 2 cm and spins a cocoon just before the pupal moult. Pupae can be found where leave damage occurs. Larvae and pupae are often hidden under leaves that are stuck together, to a branch or to a fruit (CABI, 2002). If larvae are disturbed, they let themselves fall down on a spinned thread in order to escape. This thread is also a possible method for migration by the wind (CABI, 2002). Later in the season, the

larvae are mostly present on new shoots high in the tree. The fruit damage of the first summer generation is different from that of the second summer generation. For the first, the damage of the fruits consists of large deep holes (CABI, 2002). For the second, very superficial and small holes of less than 5 mm in diameter occur. Usually, several of these holes are adjacent to each other. This damage might cause desiccation and not lead to rotten fruit, in contrast to the damage of the first generation (CABI, 2002).

Larvae hibernate in the second and third larval stages, hidden in a silken spinning in crevices on the tree trunk and branches (CABI, 2002). In March or early April activity of the larvae is resumed. In the northern hemisphere, diapausing larvae hibernate in the third stage and begin development again in the spring (Charmillot and Brunner, 1989). They migrate to the new developing buds in which they spin the rosette leaves and eventual flower parts together (CABI, 2002). Most of the damaged new fruits will fall. If not, the wounds recover and are visible as corky, well-shaped areas. This damage is not distinguishable from the damage of other species in the flowering period (CABI, 2002). *A. orana* can cause damage to more than 50% of fruit (CABI, 2002). Well-managed orchards with a lot of young shoots can be particularly infested.

Adult moths are 8-12 mm long. The wings are brownish with a variable dark-brown marking pattern and an outer costal spot is noticeable on the wings. This spot is dark brown with a variable shape. The middle marking is narrower laterally, but becomes larger or ramified to the middle. A very specific characteristic of *A. orana* is the fork-shaped structure of the veins 7 and 8 (CABI, 2002). Adults show sexual dimorphism. Male moths are smaller, have more pronounced wing markings and brighter colours. Females are more bell-shaped, with the lower tips of the wings pointing more outwards. The abdomen end of the males contains long hairs on the ventral side. Female moths have anal lobes at the end of the abdomen, which are important for mating.

In most years, there are two generations per year in north-western Europe (CABI, 2002). In warm summers, a partial third generation may appear. The onset of the flight of the males is a few days earlier than that of the females. The flight of the first generation occurs in north-western Europe from the end of May to the end of June. The second generation flies from the end of July to the beginning of September. The eventual third generation flight occurs in October. Adult moths live from 5 days to 2 weeks depending on the temperature (CABI, 2002). The flying activity is often restricted to the night (CABI, 2002). Although migration is rather limited, especially for the females, males have been found at more than 400 m from their initial location (CABI, 2002). Flight activity and mating is very restricted if the temperature is lower than 12°C.

Plant parts liable to carry *A. orana* in trade/transport include fruits which may contain larvae internally or externally and leaves which may contain eggs (CABI, 2002). Larvae are visible to the naked eye (CABI, 2002).

Control: No literature was found on the control of *A. orana* in longan and lychee orchards.

In apple and pear orchards, a model describing the life cycle as a function of temperature allows for the determination of the best time to sample damage and to apply treatments with regard to their particular mode of action. Some classical insecticides provide control curatively but efficiency is always reduced against older larvae. The best results are obtained at egg eclosion following the first flight (Charmillot and Brunner, 1989). The insect growth regulator, fenoxycarb, is very effective when applied in the spring against the fifth and final stage larvae of the overwintering generation. A specific virus also gives good control in the spring against over wintering larvae. For all the products used to control *A. orana*, the timing of the application is extremely important in order to obtain the best efficiency (Charmillot and Brunner, 1989).

Pathogens are also very important and might actively be used for the control of *A. orana*. *Bacillus thuringiensis* cv. *alesti*, *berliner*, *kurstaki*, *thuringiensis* and *aizawai* have been reported (Ioriatti *et al*., 1996). Granulosis viruses and nuclear polyhedrosis virus might also be sprayed (CABI, 2002).

Parasitoids of *A. orana* include: *Apanteles xanthostigma* and *Meteorus ictericus* attacking larvae in the Netherlands and Hungary; *Colpoclypeus florus* and *Scambus brevicornis* attacking larvae in the Netherlands, Germany and Austria; and *Teleutaea striata* attacking larvae in the Netherlands and Germany (CABI, 2002). References to natural enemies are given by Papp and Reichart (1973), You *et al*. (1983), Sheng and Kamijo (1992) and Vidal (1997).

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PATHOGENS

Cylindrocladiella disease

***Cylindrocladiella peruviana* (Batista, Bezerra & Herrera) Boesewinkel. ['Mitosporic fungi':Hyphomycetes]**

Synonym(s): *Cylindrocladium peruvianum* Batista, Bezerra & M.M.P. Herrera 1965 [teleomorph unknown]

Perally (1991) reviewed the genus *Cylindrocladium* (syn. *Candelospora*, *Teracytum*, *Acontiopsis*, *Cylindrocladiella*). In a reassessment of *Cylindrocladiella* (Crous and Wingfield, 1993), *C. peruviana* was reduced to synonomy with *C. camelliae* (Venkatarm. and Ram) Boesew. even though it has the ability to produce microsclerotia in culture. However, Crous (2002) accepted *C. peruviana* as a separate species based on the molecular work of Victor *et al*. (1998) and Schoch *et al*. (2000) confirming noted differences in vesicle taper between strains of these two species. Taxonomic clarification is a significant issue as *C. camelliae* is already present in Australia.

Common name(s): Root rot; leaf spot; fruit rot.

Host(s):

C. peruviana: *Acacia mearnsii* (late black wattle); *Aglaonema commutatum* (Chinese evergreen); *Aglaonema* sp. (Chinese ivy); ***Arachis*** *hypgaea* (peanut); *Camellia sinensis* (tea); *Chamaedorea* sp. (palm); *Cissus rhomifolia* (grape ivy); *Cupressus sempervirens* (Italian cypress); *Cyclamen persicum* (florist's cyclamen); *Dimocarpus longan* (longan) (SAIQ, 1999); *Eucalyptus* sp. (eucalypt); *Lactuca sativa* (lettuce); *Manihot esculenta* (taro); *Protea* sp. (protea); *Prunus* sp. (stonefruit) (Browne, 2001); *Solanum tuberosum* (potato); *Vitis vinifera* (grapes) *Phoenix roebelenii* (dwarf date palm); *Rhododendron* sp. (rhododendron) (Crous, 2002; SBML, 2000)

C. camelliae: *Acacia dealbata* (silver wattle; *Acacia mearnsii* (late black wattle); *Armorphallus* sp. (elephant yam); *Arenga pinnata* (arenga palm); *Camellia sinensis* (tea); *Eucalyptus* sp. (eucalypt); *Garcinia spp. (mangosteen); Mangifera indica* (mango); *Mimusops elengi* (Spanish cherry); *Myristica fragrans* (nutmeg); *Phellodendron amurense* (philodrendron); *Pinus sylvestris* (Scot's pine); *Saxifraga solonifera* (strawberry-begonia); *Synoum* sp. (rosewood); *Wisteria chinensis* (wisteria) (CIQ, 2000; Crous and Wingfield, 1993, Crous, 2002; SBML, 2000).

Plant part(s) affected: Fruit, leaf, root (AQSIQ, 2003; CIQ, 2000; SBML, 2000).

Distribution:

C. peruviana: Brazil; China (SAIQ, 1999); Japan; Peru; South Africa; United States (Hawaii, Florida) (Crous, 2002; Crous and Wingfield, 1993; Farr *et al*. 1989; SBML, 2000).

C. camelliae: Australia; Brazil; China (SAIQ, 1999); England; India; Japan; Mauritius; New Zealand; South Africa; Sri Lanka; Taiwan; Thailand; United States (Florida) (Crous, 2002; Crous and Wingfield, 1993; Farr *et al*. 1989; SAIQ, 1999; SBML, 2000).

Crous and Wingfield (1993) reported *Cylindrocladiella camelliae* in Australia on *Synoum* sp. (rosewood). *Cylindrocladium camelliae* has been recorded on *Rubus rugosus*, *Durio zibethinus*, *Banksia* sp. and *Camellia* sp. *Cylindrocladiella* sp. on *Rosa* sp. and *Mangifera indica* in Queensland (APPD, 2003).

Biology: *C. peruviana* and *C. camelliae* both have a minimum temperature requirement for growth above 5°C and a maximum of 30°C with an optimum of 25°C. They are both a high and low temperature species, with extensive sporulation on aerial mycelium (Crous and Wingfield, 1993).

The pathogen has also been isolated from ants (Batista *et al*., 1965).

Symptoms usually occur as root and cutting rot (Crous, 2002). *C. peruviana* (Batista,

Bezerra & Herrera) Boesewinkel is recorded as causing *Cylindrocladiella* root rot in *Cyclamen* sp. Pernezny and Simone (2000) list *Cylindrocladiella peruviana* (Batista, Bezerra & Herrera) Boesewinkel = *Cylindrocladium peruvianum* Batista, Bezerra and Herrera as a root rot occurring on mango.

Associated with Replant Disorder (RD) of *Prunus* spp., significant amounts of root necrosis, but not significant growth reductions, were caused by some isolates of *Cylindrocarpon* sp. and *Cylindrocladiella peruviana* (Browne, 2001).

In the Federal District in Brazil, *C. clavatum* and *C. scoparium* were isolated from cultivated and uncultivated soils, while *C. peruvianum* and *C. pteridis* were found in cultivated soils only (Almeida and Bolkan, 1981a). Almeida and Bolkan (1981b) found 38 isolates of *C. clavatum*, *C. scoparium*, *C. peruvianum* and *C. pteridis* tested in the glasshouse were pathogenic to groundnut, eucalyptus and potato, but not all infected soybean. Eucalyptus and soybean were the most and least susceptible plants, respectively.

C. camelliae affects the roots of *Camellia sinensis* (tea) causing unthrifty plants with few feeder roots, raised patches on the bark of the tap and lateral roots sometimes extending to the collar. It has also been isolated from the healthy symptomless leaves of *Acacia dealbata* in Japan (Perrally, 1974). *C. camelliae* has been recorded as a minor root rot of tea in South India (Perally, 1974).

C. peruvianum appears to mainly cause root rot and a leaf spot on hosts but is recorded on the fruit of longan in China. Fruit may become infected by wind or rain splash from the soil surface or by contact with the ground. According to Zhang *et al.* (1997) and CIQ (2000), infected fruit of longan are visible on the tree by the white mycelium and obvious decay.

The fungus sporulates easily on the mycelium.

Control: No information was available in the literature on control of this pathogen or if control other than good orchard management is necessary.

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Litchi brown blight

***Peronophythora litchii* Chen ex Ko. Chang, Su, Chen & Leu. [Pythiales: Pythiaceae]**

Synonym(s): The causal pathogen was first isolated from lychee fruit in Taiwan by Chen in 1934 and described in a new genus in 1961 (Chen, 1961; Kao and Leu, 1980). Chen placed *P. litchii* in the Peronosporaceae family. Ko *et al*. (1978) reinvestigated the morphological characteristics of the microorganism and erected the independent family Peronophythoraceae, intermediate between the Peronosporaceae and Pythiaceae to accommodate the species (CMI, 1979; Kao and Leu, 1980). Huang *et al*. (1983) amended the family description to take into account the multi-determinate nature of the sporangiophores.

Zoospores of six species of *Phytophthora*, two species of *Pythium*, *Saprolegnia diclina* and *Peronophythora litchii* were examined to resolve the orientation, extent, and possible connection of the anterior roots of the flagellar apparatus. The two roots are separate and although from some angles they appear to overlap, they do not connect. The zoospore of *P. litchii*, not previously studied in the transmission electron microscope, is cytologically similar to other zoospores in the Pythiaceae and Peronosporaceae (Barr and Désaulniers, 1997).

Common name(s): Litchi downy blight; litchi brown blight; downy blossom blight of lychee; fruit rot; root rot.

Host(s): *Litchi chinensis* (lychee). Some fruits of tomato, pawpaw and loofah have been

artificially inoculated (CMI, 1989).

Plant part(s) affected: Fruit, flower, leaf, pedicel, root (Ann and Ko, 1984; Chi *et al*., 1984).

Distribution: China (Chi *et al*., 1984); Papua New Guinea (Arentz, 1986); Taiwan (Ann and Ko, 1984; Chen, 1961; Kobayashi *et al*. 1986); Thailand (DOA, 2003); Vietnam (Vien *et al*. 2001).

Biology: The chromistan *Peronphythora litchii* is a facultative necrotroph producing colourless, aseptate mycelium 4-6 µm wide, branched irregularly at right or acute angles (Hall, 1989). Chen (1961) reported symptoms of circular, pale black-brown lesions on the rind of the fruit mainly confined to the point of contact of adjacent fruits nearing maturity. Lesions are about 1-1.5 cm in diameter and covered with pale yellowish aerial mycelia. The inner surface of the exocarp is paler than the external surface with the tissue of the stem-end also pale black-brown.

Diseased flowers and panicles turn brown and become covered with whitish masses of sporangia and sporangiophores especially when there is rain during the late infection stage. Panicles eventually dry up. Young and ripe fruits, pedicels and leaves are also attacked, with irregular brown lesions with an unclear border (Ann and Ko, 1984). Infected fruit may fall prematurely.

Continuous rain in the growing season in May in China appears important for development of an epiphytotic (CMI, 1989). The infection period was shown in laboratory studies to be short and temperature dependent, varying from 1 day at 25°C to 3 days at 18°C. Kao and Leu (1980) found that the optimum temperatures for mycelial growth, sporulation, and germination of sporangia of *P. litchii* coincide with the maturing stage of lychee fruit where the temperatures range from 20 to 28°C. Higher temperatures in the daytime is suitable for sporulation, germination, and infection by the pathogen, and lower temperatures and high humidity at night facilitate zoospore release and distribution. In China the optimal temperature for disease outbreaks is 22-25°C (Li, 1997) with rainy spring days during infection causing serious losses.

In Vietnam, the disease is worse during periods of unusually cool, wet weather (Vien *et al*., 2001). Early symptoms of infected fruit are fruit necrosis and hyphal growth on the surface. Infected fruit turn brown and become enveloped in a white downy growth of hyphae, sporangiophores and sporangia (Vien *et al*., 2001). In 2000, in the Thanh Ha district of Hia Duong Province, downy blight affected 26% of blossoms in March and up to 12% of fruit in May. Similar symptoms had been observed in Vietnam in 1993 on both blossoms and fruit, and in 1998 and 1999 on blossoms only (Vien *et al*., 2001).

The pathogen remains in the soil or on infected fruit skins over-wintering mostly in spores. Spores germinate and spread as sporangia. Sporangia are not liberated by moving air, but

are readily dispersed in splash droplets, suggesting a rain-splash mechanism (CMI, 1989) and may be further spread by insects. Sexual reproduction has not been observed on fruit (Vien *et al*., 2001). Isolates of *P. litchii* collected in Taiwan from diseased lychee fruit were shown to cause disease symptoms when inoculated onto both wounded and unwounded mature fruit, suggesting that the disease could develop in the field without mechanical injury (Chen *et al*., 1998).

The nutritional requirements of the chromistan are similar to those of *Phytophthora* and amylase activity has been detected from mycelium (Huang *et al*., 1983). Ou *et al*. (2000) compared the two most widely grown lychee cultivars in southern China, 'Huaizhi' and 'Nuomici' for their response to infection by *P. litchii*. The level of chitinase, ß-1,3-glucanase, antioxidant enzymes peroxidase, and antioxidants glutathione and ascorbate were higher in 'Huaizhi' which combined with a much more compact peel structure, was more storable than 'Nuomici'.

P. litchii is an important fruit disease of lychee in Taiwan, China and recently Thailand and Vietnam (Coates *et al*., 2003) and is considered to be one of the most important diseases of lychee in China (Ou, 2001; Zhang, 1997).

Infection of the fruit causes loss of fruit and low commercial value of postharvest fruit due to off-taste and shortened shelf life (Ou, 2001).

In Guangzhou (Guangdong Province), *P. litchii* was recorded causing death of flowers and fruit decay; yield losses of 10-30% and losses of up to 50% with severe infections (Ou *et al*., 1999).

It caused about 60% losses in the Nan-tou area of Taiwan in 1977. Extensive drop of infected fruit occurs in Taiwan during May and June which coincides with the beginning of the rainy season and the ripening phase of fruit development (Kao and Leu, 1980). In 1983, in central and southern Taiwan, a blossom blight of lychee was reported to cause considerable reduction in yield of lychees. Diseased flowers turned brown and were covered with whitish masses of sporangiophores and sporangia. *P. litchii* was isolated from diseased flowers and reisolated from experimentally infected flowers (Ann and Ko, 1984).

Kobayashi *et al*. (1986) indicated that *P. litchii* was isolated from lychees imported from Taiwan to Japan

Molecular markers for the detection and diagnosis of *P. litchii* have been developed (Chen *et al*., 1998b) which would enable detection of the pathogen on the fruit and in the soil directly from the field to assist in further study of the ecological roleof disease development and genetic diversity of oomycetes.

Control: There is little information available on control of this disease other than by orchard management. This includes removal of infected and dead branches during post-

harvest pruning; winter orchard cleaning and winter spraying of the crowns of trees with 50% copper oxychloride solution (1:600) (Li, 1997).

In China, chemical control in the spring, when temperatures are higher and soil humidity higher includes two sprays of 0.2%-0.3% copper sulphate with a surfactant on the ground prior to an application of lime (CIQ, 2000; Zhang, 1997). Chemical control options recommended in China at flower budding stage, fruitlet stage and on pre-ripe fruit stage are 90% aliette solution (1: 400-500) and 58% Ridomil Mz or 64% Sadofan (1:600). Where infection is severe, two applications are required at flower budding in mid to late March (Li, 1997).

Ou (1999) reported control with mancozeb applications. Li and Wu (2000) compared Metalaxyl, Oxadixyl, Curzate-M8 (8% Cymoxanil and 64% Mancozeb) and Mancozeb in the control of the disease and found Metalaxyl to have the highest toxicity with Mancozeb the lowest. However, some phenylamide-resistant pathogens have been found in some regions but no cross-resistance was found between Metalaxl and Cymoxanil.

Zentmyer and Mitchell (1985/86) suggested that many of the control measures for *Phytophthora* diseases of tropical fruit tees would also apply to control of *Peronophythora* fruit rot due to similarities between the two genera.

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Fruit blotch

***Phomopsis longanae* Chi & Jiang [Diaportales: Valsaceae]**

Synonym(s): None known.

Common name(s): Branch canker; fruit blotch; fruit rot.

Host(s): *Dimocarpus longan* (longan); *Litchi chinensis* (lychee) (Lin and Chi (1992).

Plant part(s) affected: Bark, fruit, stem, twig (DOA, 2003a, b).

Distribution: China (Lin and Chi, 1992).

Biology: Coates *et al*. (2003) list *Phomopsis* sp. causing leaf spot on lychee and a die-back disease of lychee in Florida (Alfieri *et al*., 1994); leaf spot of rambutan (Tindall, 1994) and stem-end rot of longan, lychee and rambutan.

Phomopsis sp. are implicated along with *Diplodia theobromae* and anomorphs of *Botryosphearia* spp.as well as *Colletrotrichum* spp. as the most common causal agents of stem-end rot on longan, lychee and rambutan (Coates *et al*., 2003). Stem-end rots begin as brown discolouration of the rind at the stem end and expand rapidly and are visually indistinguishable without isolation.

The process of infection is not been clearly established. Symptoms probably arise from quiescent infections in the skin and stem end of fruit (Coates *et al*. 2003). *Phomopsis* sp. has also been isolated as an endophyte from longan, lychee and rambutan stem tissue, suggesting another mode of infection (Johnson *et al*., 1998).

Phomopsis caricae-papayae on mango is spread by spores on the stalks spreading to fruit in wet weather. Latent infections may form on the pericarp or stem end prior to harvest. Alternatively, spores on the fruit surface may germinate and enter through cut stem end. Spread of *Phomopsis* disease from fruit to fruit after harvest is not significant in mango

(Persley, 1993). Symptoms commonly occur at the stem end but can occur anywhere on the fruit initially as water-soaked lesions. The rot develops deep into the flesh. At advanced stages, white mycelium with numerous black pycnidia may be visible (Persley, 1993).

The record of the pathogen *Phompsis longanae* on longan in China is relatively recent (Lin and Chi, 1992) and the damage on longan in China is reported to be low (AQSIQ, 2003).

Control: Coates *et al*. (2003) suggests that inoculum from the group of fungi causing stem end of longan, lychee and rambutan rot can be reduced by pruning out dead leaves and twigs in the canopy, thus increasing ventilation and providing a less favourable environment.

Fruit should be cool-stored after harvest to suppress the development of disease and fungicide treatment can provide some control.

For *Phomopsis mangifera* and other pre- harvest rots in mangoes dipping in hot (52ºC) benomyl for 5 minutes is effective but increasingly not allowed in many areas. Hot water treatment at 55ºC or vapour heat treatment are less effective. Treatment with fungicide prior to storing for long periods is recommended (Ploetz, 2003).

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Phytophthora fruit and rot

***Phytophthora palmivora* MF4 (E. J. Butler) E. J. Butler [Pythiales: Pythiaceae]**

Synonym(s): *Phytophthora arecae* (L.C. Coleman) Pethybr.; *Phytophthora cactorum* var. *arecae* (L.C. Coleman) Sacc. & Trotter; *Phytophthora faberi* Maubl.; *Phytophthora heveae* A.W. Thomps.; *Phytophthora omnivora* var. *arecae* L.C. Coleman; *Phytophthora palmivora* var. *heveae* (A.W. Thomps.) Orellana; *Phytophthora palmivora* var. *theobromae* (L.C. Coleman) Orellana; *Phytophthora theobromae* L.C. Coleman (CABI, 2002).

Common name(s): Phytophthora leaf blight and fruit rot (Coates *et al*., 2003); black pod of cacao (CABI, 2002).

Host(s): *P. palmivora* infects more than 200 species of economic, ornamental, shade and hedge plants. Primary hosts include: *Areca catechu* (betelnut palm), *Carica papaya* (pawpaw), *Cocos nucifera* (coconut), *Dimocarpus longan* (longan) (DOA, 2003b); *Hevea brasiliensis* (rubber), *Litchi chinensis* (lychee) (DOA, 2003a); and *Theobroma cacao* (cocoa).

Secondary hosts include: *Anacardium occidentale* (cashew nut), *Ananas comosus* (pineapple), *Annona muricata* (soursop); *Annona glabra* (pond apple); *Areca* sp. (areca palm*), Artocarpus altilis* (breadfruit), *Citrus* spp. (citrus), *Citrus x paradisi* (grapefruit), *Durio zibethinus* (durian), *Elaeis guineensis* (African oil palm), *Ficus carica* (common fig), *Gossypium hirsutum* (Bourbon cotton), *Mangifera indica* (mango); *Manihot esculenta* (cassava), *Manilkara zapota* (sapodilla), *Myristica fragrans* (nutmeg), Palmae (plants of the palm family), *Persea americana* (avocado), *Piper nigrum* (black pepper) (CABI, 2002; Ploetz *et al*., 2003).

Plant part(s) affected: Fruit, leaf, panicle, root, young shoots (CABI, 2002; Coates *et al*., 2003; DOA, 2003a, b).

Distribution: Worldwide distribution, ubiquitous in the tropics (CABI, 2002) including Australia (Northern Territory and Queensland) (APPD, 2003; CABI, 2002); China (Fujian, Jiangsu, Taiwan, Yunnan, Zhejiang) (CABI, 2002); Thailand (Phitsanulok, Chiang Mai Province (CABI, 2002; DOA, 2003a, b).

Biology: Symptoms in longan include a dark necrosis of young shoots, brown blight on the

panicles, flower drop, irregular brown lesions on fruit and premature fruit drop. During wet weather the fruit will crack and lesions will be covered by white sporangia and sporangiophores (Coates *et al*., 2003).

In longan and lychee, infection occurs by zoospores, released when there is free moisture. The disease then develops during extended periods of wet weather (DOA, 2003a, b).

In Thailand, it is considered a moderately important disease of longan causing fruit rot and lychee mostly causing root rot (DOA, 2003a, b). It is possible that low hanging longans or lychees or fallen fruit may be infected and rot. Phytophthora leaf blight and fruit rot are serious diseases of longan where fruit are induced to set during the off-season (Visitpanich *et al*., 2000). The symptoms develop during cool weather especially after 2-3 days of rainfall (Bhavakul *et al*., 1998).

P. palmivora can survive dry periods as dormant chlamydospores, oospores or dormant mycelium, and produce sporangia and zoospores when the rain returns. Chlamydospores are also found in fruit tissue and are most important survival structure (CABI, 2002).

P. palmivora infects more than 200 species of economic, ornamental, shade and hedge plants. All palms are potentially affected; *Cocos nucifera* and *Areca catechu* are most commonly infected (CABI, 2002). It causes fruit rot in atemoya, breadfruit, papaya, pond apple, soursop, fig, longan and durian (Ploetz *et al*., 2003).

In cocoa, the whole plant is attacked resulting in pod rot, bark and stem and cushion canker, wilt and blight. Circular brown lesions develop on pods eventually blackening and mummifying the pod sometimes covered in a white mass of sporangia (CABI, 2002). Low initial inoculum can build up rapidly by repeated cycles of sporangia and zoospores production due to a very short regeneration time. Above ground sources of infection such as mummified pods, infected flowers and cankers are important for primary infection with rain splash on the soil and diseased pods and leaves creating droplets which move upwards with convection and can also be moved by insect vectors such as ants. Cankers can also form in wounds after insect injury (CABI, 2002). Rain splash is also responsible for transmission of rubber leaf disease and papaya root rot liberating sporangia from infected leaves and fruit and from soil into the air. Wind dispersal of inoculum and windblown rain permits spread and developments of epidemics (CABI, 2002).

Recent estimates attribute 44% of the total global crop loss of cocao to black pod disease (Van der Vossen, 1997). *P. palmivora* is a serious pathogen in West Africa where over 60% of global cocoa is produced. Pod rot and stem canker caused cocoa pod losses of up to 63% and the death of up to 10% of trees annually on Kar Kar Island, Papua New Guinea (Guest *et al*., 1994). There were substantial losses due to papaya root rot in south-eastern Queensland in the 1950s and more than 20% of plants were destroyed in one papaya plantation in central Taiwan in 1975 (Ko, 1994). Pineapple heart rot is a problem in Australia, the Philippines, South Africa and Thailand, but worldwide losses are highly

variable (CABI, 2002).

Control: Control in longan and lychee orchards is achieved through good orchard sanitation, with destruction of diseased plant material to reduce the source of inoculum. Fungicide applications may be necessary during disease conducive periods. The soil at the base of the tree trunk can be drenched with metalaxyl as an effective chemical control of this disease (DOA, 2003a).

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Longan witches' broom disease

Longan witches' broom (aetiological agent unconfirmed)

Common name(s): Longan witches' broom

Host(s): *Dimocarpus longana* (longan) (DOA, 2003b; Qui, 1941); *Litchi chinensis* (lychee) (Chen I., 1996) but questioned by AQSIQ (2003).

Plant part(s) affected: Flower, leaf, seed, shoot (Chen *et al*., 2001; Menzel *et al*., 1989).

Distribution: Brazil, China (Guangdong, Guangxi, Hainan, Hong Kong), Taiwan, Thailand (Kitijima *et al*., 1986; Koizumi *et al*., 1995; Menzel *et al*., 1989; So and Zee, 1972; Zhu *et al*., 1994).

Biology:

Longans: The earliest description of this disease on longans is by Qui (1941). Young leaves of infected shoots are small and light green in colour, with curved margins. They appear stunted and deformed, and tend to roll up rather than expand (Zhang and Zhang, 1999). Adult leaves are light yellow-green with marbled yellow spots and brown veins. Leaves form blisters and become distorted and dry before falling off (Menzel *et al*., 1989; Zhang and Zhang, 1999). Shoots on infected branches become compacted clusters and the inflorescences are unable to extend. The flower organs develop abnormally, and consequently, the flowers either fail to produce fruits or develop into small and empty fruits. A characteristic symptom of the disease is the loss of flowers from panicles, resulting in a 'broom-like' appearance of inflorescences (Menzel *et al*., 1989).

In Thailand there are reports of fine light green hairs forming an erinium on both sides of affected leaves. *Aceri dimocarpi* mites reside inside the erinium mass (Visitpanich *et al*., 1996).

Different cultivars of longan vary in their sensitivity to damage by this disease (So and Zee, 1972). Although the causal organism appears to be systemic, not all branches of an infected tree show symptoms of the disease (Vera and Zee, 1972). Symptoms of longan witches' broom resemble those described for lychee witches' broom (Chen *et al*., 1996; Koizumi, 1995). A study conducted in Hong Kong revealed that disease symptoms were more frequent on younger trees (10-25 years) than on older trees (30 years) (So and Zee,

1972). However, there is disagreement among the available literature as to whether longan witches' broom is caused by a virus (Chen *et al*., 1996; Chen *et al*., 2001; So and Zee, 1972; Ye *et al*., 1990), a mycoplasma (MLO) (Menzel *et al*., 1989), or a mite (He *et al*., 2001).

Several studies indicate that the causal agent of the disease is viral. So and Zee (1972) carried out electron microscopy of ultrathin sections from diseased leaves and found filamentous particles that measured about 12 nm in diameter and about 1000 nm in length. The virus particles seemed to be restricted to the sieve tubes, and in the mature sieve tubes appeared to be closely associated with the plasma lemma and the cell wall. They were rarely present in the lumen of the sieve tubes and have never been seen in the non-infected tissues. These virus particles seldom occurred singly, but usually in a cluster. Ye *et al*. (1990) partially purified a filamentous virus from the leaves and bark of infected longan trees and reported filamentous virions with a diameter of about 15 nm and a length of 300-2,500 nm, with most 700-1300 nm in length.

Details of longan witches' broom virions from diseased trees were detected by means of an enzyme linked immuno sorbent assay (ELISA). Chen *et al*. (1996) also found filamentous virus particles in leaf phloem cells of infected plants. Using immuno sorbent electron microscopy (ISEM) technique, filamentous viral particles were trapped from the extract preparations of diseased plant materials and the salivary glands of *Corngenasylla sinica* (longan psylla) and *Tessaratoma papillosa* (litchi stink bug) (Chen *et al*., 1994). From these results, Chen *et al*. (2000) concluded that the disease is caused by a filamentous virus.

Since no photos of the virus were available and the experimental results were not replicated, the existence of a virus pathogen of the disease remained controversial. In order to clarify the cause, a series of research projects have been conducted since 1986 in the Fujian Academy of Agricultural Sciences. Other organisms such as a phytoplasm (= MLO) and twig borer insects were suspected of being the causal agent (Li, 1983), although administration of anti-biotic treatments to seedlings failed to suppress the disease, indicating that a phytoplasm was unlikely to be the cause (Chen *et al*., 1989).

He *et al*. (2001) carried out investigations in orchards in Guangdong Province between 1995 and 1998, and reported that longan witches' broom is caused by the mite *Eriophyes dimocarpi* Kuang, and not by a virus or a twig borer. They observed that witches' broom diseased shoots could occur both in the presence and absence of twig borer tunnel damage. However, when longan seedlings were inoculated with mites, 50% developed symptoms of witches' broom disease and hosted mites, whilst no mites were found on the leaves of the symptomless plants. The mite was always found to exist on diseased shoots and spikes, and the number of mites was positively correlated to the severity of the disease. Integrated management of pruning and spraying with a mitecide on diseased shoots restored blossoming and reduced the average incidence of diseased spikes from 80% to 9% in three

orchard trials. Further evidence of a mite being implicated in the witches' broom disease has been reported in Chiang Mai and Lam Phun provinces of Thailand, where the aetiology is thought to be the mite *Aceria dimocarpi* (Kuang) and a transmitted phytoplasma (Chantrasri *et al*., 1999; Visitpanich *et al*., 1999). After one month, feeding by the mites caused witches'broom symptoms along the shoot of seedlings. Electron micrographs revealed phytoplasma cells in the cytoplasm of infected sieve tube elements and were confirmed by PCR techniques (Chantrasri *et al*., 1999). However, Sdoodee *et al*. (1999) were not able to confirm the presence of phytoplasmasa in infected longan tissue with PCR despite the DNA indicated the presence of a prokaryote.

Studies relating to the transmission of the 'virus' were undertaken from 1985-89 by Chen *et al*. (1992). It was found that longan witches' broom was transmitted from one longan tree to another and from longan to lychee trees by the vectors *Tessaratoma papillosa* Drury (litchi stinkbug) and a longan psyllid, *Cornegenasylla sinica* (Koizumi, 1995). The transmission rate by adults and nymphs of the litchi stink bug was 18.8-36.7% and 26.7-45%, respectively, with the latent periods ranging from 53-72 days up to one year. The transmission success rate by the longan psylla was 23.3-36.7% with a latent period of the disease from 80-88 days up to one year.

Transmission has also been demonstrated by inarching or marcotting from diseased parent trees (Li L.R., 1955; Menzel *et al*., 1989).

Another possible vector of longan witches' broom is dodder weeds. A study of transmission by *Cuscuta campestris* (dodder) conducted in 1987 and 1988 in China, found that infectivity caused by the dodder weeds was 20-40% with a latent period of 130-136 days (Chen *et al*., 1990b). Dodder feeding on infected longan shoots was able to transfer the phytoplasma and produce symptoms in periwinkle plants (*Catharanthus rosea*) (Chantrasri *et al*., 1999).

A preliminary survey of the incidence of the disease in Hong Kong indicated that witches' broom of longan was most likely to have originated from Kwantung, China (Li L.R., 1955), where the proprietors of the local orchards obtained planting materials. A study that followed the discovery of the disease in Hong Kong, indicated transmission of the disease via seeds and grafting prompting Li L.R. (1955) to suggest that the cause of longan witches' broom may be viral. So and Zee (1972) grafted seriously infected longan trees onto two-year old disease-free trees. Seven months later, typical symptoms were evident on the young foliage of all test plants, with the exception of one that failed to graft. The controls did not show virus symptoms. These results agreed with preliminary findings by Li L.R. (1955) on the transmission of the disease in China.

Chen and Ke (1994) reported that the incidence of the disease on seedlings in Fujian Province was 5-30%, while the incidence after grafting onto three different longan varieties was 4.3, 14.0 and 19.4% respectively. Longan witches' broom has spread quickly

in Guangdong Province in China with 11% of trees infected in 1995 rising to 50% by 1997.

Results obtained in a grafting test indicated that scions may have caused 4.26-19.44% morbidity of the graftlings, which showed symptoms of the disease within 3-10 months (Chen *et al*., 1990b). An investigation revealed that the morbidities of seedlings, aerial layerings and tongue graftings in the field were 0.1-45.2%, 21-32% and 5-20%, respectively (Chen and Ke, 1994). The extremely high morbidity of seedlings in the field was most likely to be caused by repeated infection by insect vectors.

Seedlings grown from the seeds of infected trees cultivars 'Youtanben' and 'Dongbi', showed an average morbidity of 2.17% (0.19-4.41%) (Chen *et al*., 1990b), suggesting that seed of the fruit was one of the factors spreading the virus (Chen *et al*., 1992) supporting the work of Li (1955). In another test, pollen from diseased flowers of longan were aseptically cultured and typical symptoms of longan witches' broom were present on some of the anther-derived plantlets, indicating that the pathogen may have been transmitted by pollen (Chen *et al*., 1990b). It remains uncertain whether pollen of the infected longan flowers carried the virus, however, the healthy leaves smeared with the juice of young leaves from diseased trees did not develop any symptoms of the disease (Chen *et al*., 1990b) excluding the possibility of virus transmission by sap smearing.

Chen *et al*. (2001) reported after conducting further transmission tests suggesting that the seeds and budwoods of longan; insects, litchi stink bug (*Tessaratoma papillosa*) and longan psylla (*Cornegenapsylla sinica*); and dodder plants (*Cuscuta campestris*) were positive in transmitting this virus.

Witches' broom has variously been described as 'the only significant disease affecting longan in Asia' (Menzel *et al*., 1989), as 'a widely spread and most important longan disease in China' and 'most serious disease to the crop' (Chen *et al*., 1992).

An early survey in China revealed that 80-100% of longan trees in an old orchard, and 5-10% in newly established orchards were attacked by witches' broom disease (So and Zee, 1972). According to an investigation conducted into longan production areas in 17 counties or cities in Fujian Province of China, the percentage of diseased trees varied from 20-100% with higher infestation in mature groves. The disease causes crop losses of 10-20% in average years, whilst crop losses of over 50% have been recorded in some severe cases (Chen *et al*., 1990a).

Lychee: Chen *et al*. (1992) report that witches' broom symptoms have been observed on lychee in Fujian Province for 10 years. The disease is transmitted by seedling, inarching and by the vector, *Tessaratoma papillosa*, and is also associated with the presence of filamentous virus particles in leaf phloem cells. This suggests that lychee and longan witches' disease are caused by the same virus (Chen *et al*., 1996). Lychee witches' broom is known to infect seedlings, juvenile and adult trees. Young leaves on the shoots of

infected plants become rolled and reduced in size, with excessive proliferation of shoots that become broom-like in appearance. The flowering panicles become considerably aggregated in clumps and resemble those described for longan witches' broom. Chen *et al*. (1992) reported that longan witches' broom disease is closely related to that of lychee, because *Tessaratoma papillosa* can successfully transmit the pathogen of longan witches' broom to lychee.

However, other Chinese technical experts reported a lack of adequate evidence to prove that witches' broom disease infects lychee fruit or that the disease exists in lychee (AQSIQ, 2003).

Witches' broom disease has never been recorded on lychee in Thailand (DOA, 2003).

Control: The pathogen may be controlled by integrated methods, including strict quarantine of longan material from infected areas; use of resistant varieties; careful selection of propagating material and virus-free seedlings; and chemical control of the vectors (Coates *et al*., 2003). The best strategy for disease management appears to be controlling the vectors (Chen *et al*., 2001; Zhang and Zhang, 1999). It was found that spraying with chlorophos (trichlorfon) or with Sumicidin gave good control of the vector (Chen *et al*., 1999b).

In Thailand, sucking insects were controlled with carbaryl and infected trees injected with the anti-biotic Pyrrodinimethyl tetracycline (PMT) near the affected tip. The tip was then cut and in 1-2 months the disease allegedly disappeared (Ungasit *et al*., 1999).

Experiments to eliminate the virus from planting material showed that alternative heat treatments at 40°C in daytime and 30°C at night for 40-90 days gave a disinfection rate of 10-20%. Shoot-tip culture gave a rate of 18.5%, and the combination of alternate heat treatment and shoot-tip culture, gave 47.3%. Virus-free plantlets were obtained by heat treatment and used as scions (Chen *et al*., 1999a). Biological and timely chemical control of insect vectors, and removal of the infected branches and inflorescences were also important measures for the management of the disease (Chen, 1990; Chen *et al*., 1990).

The close relationship between different varieties of longan and the incidence of disease was first observed in China in the mid-1980's (Chen *et al*., 1990a), but few further investigations have been made since. Chen *et al*. (1988) found great differences in susceptibility to the disease among longan varieties, and suggested careful selection and breeding as an important means of control. Varieties such as 'Lidongben' and 'Shuinan No. 1' were found to be highly resistant, whilst 'Pumingyan', 'Youtanben', 'Dongbi', and 'Honghezgi' were more susceptible. Top grafting with scions of resistant varieties effectively reduced the morbidity caused by the disease in severely infected orchards. However, none of the longan cultivars from China, Hong Kong or Thailand can be guaranteed to be free of the virus. Consequently, Menzel *et al*. (1989) advised that all longan [nursery] material introduced into Australia should be closely examined for

symptoms of the mycoplasma.

In Thailand, the popular longan cultivar 'Biew Kiew' and 'Deang Klom' and 'Ma Teen Klong' are the most prone to witches broom and develop severe symptoms (Ungasit *et al*., 1999; Visitpanich *et al*., 1996); however, cultivars 'Daw' and Heaw' are only mildly affected (Visitpanich *et al*., 1996). The longan cultivar of choice for export is 'Daw' which is considered resistant (DOA, pers. comm., 2003).

Based on the knowledge of the pathogen, its transmission sources and vectors and the principles of pest control (Chen *et al*., 1999b), six measures have been proposed for an integrated pest management program: strict quarantine inspection; selection and use of disease-resistant varieties (e.g. 'Lidongben' and 'Shuinan No. 1'); establishment of virus-free nurseries; timely control of vectors; removal of infected branches, inflorescences and trees from nurseries and orchards; and judicious fertilisation, irrigation and soil management to promote tree vigour and enhance resistance to the disease (Chen *et al*., 2001).

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