Review

Host plants and associated trophobionts of the weaver ants *Oecophylla* spp. (Hymenoptera: Formicidae)

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Abstract

Weaver ants (*Oecophylla* spp.) are often found on plants with insect symbionts (trophobionts), but the extent of such associations is not known. Examination of literature records of weaver ant host plants from 1900 to 2006 revealed that *Oecophylla smaragdina*, native to Asia, was recorded on 175 plant species in 46 families, with 28 associated trophobiont species in 7 families. *Oecophylla longinoda*, native to Africa, was recorded on 66 plant species in 34 families with 17 associated trophobiont species in 6 families. Both *Oecophylla* spp. shared host records on 17 economically important plant species. Such host plants could be used to augment establishment of weaver ants, facilitating their role as deterrents of phytophagous insect pests of economically important plants. *O. smaragdina*-tended trophobionts were recorded associating with the ants on several crops but rarely considered to be pests. Thus, the risk of trophobionts associated with *Oecophylla* ants being pests is considered minimal.

Keywords: *Oecophylla smaragdina*, *Oecophylla longinoda*, Host plant species, Trophobionts, Biological control

Introduction

The weaver ants, *Oecophylla smaragdina* Fabricius in Southeast Asia, Australia and the Western Pacific Islands [1] and *Oecophylla longinoda* Latrielle in Africa [2], have been studied for decades. *O. smaragdina* has been used by Chinese farmers to protect citrus crops since 304 A.D. [3]. Many studies on the bionomics of this ant genus [4–9] are from its application in the field. Farmer-friendly guides on applying *O. smaragdina* to fruit trees [10] and cashew [11] also exist that synthesize knowledge available on the ant in those habitats.

Oecophylla spp. form nests on a large number of host plant species. *O. smaragdina* is an effective biological control agent on host plants such as cashew [12], citrus [13] and mahogany [14] while *O. longinoda* has recently been reported to protect mango crops in Africa [15]. Host plants provide foliage the ants need to build nests with. *O. smaragdina* typically uses leaves of a certain 'normal' size that are not very waxy [8] and has been observed to favour certain plant species [5] but can construct nests with most leafy foliage. The ants can utilize many plants in a wide range of habitats [1]. Host plants also serve as an arboreal hunting ground provisioned with insects and other arthropods that the ant preys on, support trophobiont species (e.g. mealybugs and scale insects) that the ant tends for honeydew and nectar exudates that the ant consumes [16].

The references for host plants are fragmented, with the more extensive lists published by Way [4] for *O. longinoda*, and Begg [17], Peng *et al.* [6, 7] and Blüthgen *et al.* [16] for Australian *O. smaragdina*. Since the host plants in these lists and other references include those of economic value, all of which could derive benefit from weaver ant occupancy, the prospective applications for this biological control agent are considerable. This review brings together all host plant species records for *Oecophylla* spp. published since 1900. It may serve as a reference to screen for host plant species to which weaver ant protection could be applied, as well as hint towards possible

Table 1 Records of *Oecophylla smaragdina* on confirmed and possible host plants, with associated trophobionts from a survey of the literature (1900–2006). Currently accepted species and family names are used followed by names given in the original article within square brackets [ ], where different

Host plant species[1]	Associated trophobiont	Fam[2]	References	Ctry[3]
1. Anacardiaceae				
B1. *Anacardium occidentale* L.	*Egropa malayensis* Dist.	MEM	[27]	MYS
	Zesius chrysomallus Hubner	LYC	[28]	LKA
	–		[6, 7]	AUS
B2. *Buchanania arborescens* (Blume) Blume	*Arhopala micale* Boisduval	LYC	[29]	AUS
B3. *Buchanania obovata* Engl.	*Arhopala centaurus* Fabricius	LYC	[29]	AUS
C1. *Mangifera indica* L.	–	–	[30]	IND
	–	–	[6, 7]	AUS
	Mealybug sp.	PSE	[31]	VNM
	Scale insect sp.	COC+	[31]	VNM
	Scale insect sp.	COC+	[–[4]]	BEN
	–	–	[5]	MYS
A1. *Pleiogynium timoriense* (DC.) Leenh. [*Pleiogynium timorense*]	–	–	[32]	AUS
A2. *Spondias dulcis* Sol. ex Parkinson	–	–	[33]	VNM
2. Annonaceae				
A3. *Annona glabra* L.	–	–	[33]	VNM
C2. *Annona muricata* L.	Mealybug sp.	PSE	[34]	SLB
	Scale insect sp.	COC+	[34]	SLB
A4. *Polyalthia holtzeana* F. Muell.	–	–	[17]	AUS
A5. *Polyalthia nitidissima* (Dunal) Benth.	–	–	[17]	AUS
3. Apocynaceae				
A6. *Alstonia actinophylla* (A. Cunn.) K. Schum.	–	–	[6, 7]	AUS
A7. *Dyera costulata* (Miq.) Hook. f.	–	–	[35]	MYS
* *Ichnocarpus frutescens* R. Br.	–	–	[16]	AUS
A8. *Melodinus australis* Pierre	*Milviscutulus* sp.	COC	[8]	AUS
A9. *Plumeria obtusa* L.	–	–	[6, 7]	AUS
* *Wrightia laevis* subsp. *millgar* (Bailey) Ngan [ASCL]	–	–	[16]	AUS
A10. *Wrightia pubescens* R. Br.	–	–	[17]	AUS
4. Arecaceae				
* *Archontophoenix alexandrae* (F. Muell.) F. Muell. Ex Benth.	–	–	[16]	AUS
D1. *Areca catechu* L.	*Cerataphis lataniae* Boisduval	APH	[36]	IND
	Icerya aegyptiaca Doug	MAR	[36]	IND
A11. *Carpentaria acuminata* Becc.	–	–	[6, 7]	AUS
A12. *Caryota mitis* Lour.	–	–	[6, 7]	AUS
D2. *Cocos nucifera* L.	*Laingiococcus painei* Laing	PSE	[37]	SLB
	Scale insect sp.	COC	[38]	PNG
	–	–	[39]	LKA
C. nucifera L. [PALM]	*Maculicoccus malaitensis* (Cockerell)	PSE	[40]	SLB
	Mutabilicoccus simmondsi (Laing) comb. nov.	PSE	[40]	SLB
	–	–	[41]	PHL
	Mealybug sp.	PSE	[5]	MYS
	Scale insect sp.	COC	[5]	MYS
	–	–	[6, 7]	AUS
* *Licuala ramsayi* (F. Muell) Domin	–	–	[16]	AUS

A13. *Livistona humilis* R. Br.	–	–	[6, 7]	AUS
* *Normanbya normanbyi* (W. Hill) L.H. Bailey [PALM]	–	–	[16]	AUS
5. Bignoniaceae				
* *Neosepicaea jucunda* (F. Muell.) Steenis		–	[16]	AUS
A14. *Tabebuia pallida* (Lindl.) Miers	–	–	[6, 7]	AUS
6. Boraginaceae				
A15. *Cordia curassavica* (Jacq.) Roem. & Schult	–	–	[42]	MYS
B4. *Cordia dichotoma* G. Forst.	*A. micale*	LYC	[29]	AUS
7. Burseraceae				
A16. *Canarium album* Raeusch	–	–	[3]	CHN
A17. *Canarium australianum* F. Muell.	–	–	[17]	AUS
8. Cannabaceae				
* *Aphananthe philippinensis* Planch. [ULM+]	*Nacaduba berenice* Herrich–Schäffer	LYC	[29]	AUS
A18. *Celtis philippensis* Blanco [*Celtis philippinensis*]	–	–	[17]	AUS
9. Capparaceae				
A19. *Capparis sepiaria* L.	–	–	[17]	AUS
10. Caricaceae				
A20. *Carica papaya* L.	–	–	[43]	MYS
Casuarinaceae				
Casuarina sp.	–	–	[32]	AUS
11. Chrysobalanaceae				
B5. *Maranthes corymbosa* Blume	*A. centaurus*	LYC	[29]	AUS
B6. *Parinari nonda* Benth.	*A. micale*	LYC	[29]	AUS
12. Clusiaceae				
B7. *Calophyllum inophyllum* L.	*A. micale*	LYC	[29]	AUS
C. inophyllum L. [*Colophylum inophilum*] [GUTT]	–	–	[6, 7]	AUS
A21. *Garcinia mangostana* L.	–	–	[44]	AUS
13. Combretaceae				
B8. *Lumnitzera racemosa* Willd.	*Hypolycaena phorbas* F.	LYC	[29]	AUS
B9. *Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	*Z. chrysomallus*	LYC	[28]	LKA
D3. *Terminalia catappa* L.	*A. centaurus*	LYC	[29]	AUS
	Arhopala madytus Fruhstorfer	LYC	[29]	AUS
*	*Theclinesthes miskini* T.P. Lucas	LYC	[29]	AUS
A22. *Terminalia grandiflora* Benth. [*Terminalia grandeflora*]	–	–	[6, 7]	AUS
B10. *Terminalia melanocarpa* F. Muell.	*A. centaurus*, *A. madytus*, *H. phorbas*	LYC	[29]	AUS
B11. *Terminalia muelleri* Benth.	*A. centaurus*, *A. micale*	LYC	[29]	AUS
B12. *Terminalia sericocarpa* F. Muell.	–	–	[17]	AUS
T. sericocarpa F. Muell. [*Terminalia seriocarpa*]	*A. centaurus, A madytus*	LYC	[29]	AUS
Terminalia spp.	Scale insect sp.	COC+	[45]	AUS
14. Convolvulaceae				
* *Ipomoea indica* (Burm.) Merr.	–	–	[16]	AUS
B13. *Merremia peltata* Merrill	*Milviscutulus* sp.	COC	[8]	AUS
	Sextius cf. '*kurandae*'	MEM	[8]	AUS
15. Dipterocarpaceae				
B14. *Balanocarpus heimii* King	*Anthene emolus goberus* Fruhstorfer	LYC	[35]	MYS
A23. *Shorea talura* Roxb.	*Coccus* sp. [*Lecanium* sp.]	COC	[46]	IND

Table 1 (Continued)

Host plant species[1]	Associated trophobiont	Fam[2]	References	Ctry[3]
16. Ebenaceae				
A24. *Diospyros calycantha* O. Schwarz	–	–	[17]	AUS
Elaeocarpaceae				
* *Elaeocarpus angustifolius* Blume	–	–	[16]	AUS
17. Euphorbiaceae				
A25. *Croton schultzii* Benth.	–	–	[17]	AUS
A26. *Croton verreauxii* Baill.	–	–	[17]	AUS
* *Endospermum myrmecophilum* L.S. Sm.	–		[16]	AUS
B15. *Hevea brasiliensis* (Willd. ex A.H.L. Jussieu) Müll. Arg	*Parasaissetia nigra* (Neitner) [*Saissetia nigra* (Nietn.)]	COC	[47]	MYS
* *Homalanthus novoguineensis* (Warb.) K. Schum.	–	–	[16]	AUS
* *Macaranga involucrata* subsp. *mallotoides* (F. Muell.) L.M. Perry	–	–	[16]	AUS
* *Mallotus mollissimus* (Geiseler) Airy Shaw	–	–	[16]	AUS
* *Rockinghamia angustifolia* (Benth.) Airy Shaw	–	–	[16]	AUS
18. Fabaceae				
A27. *Abrus precatorius* L.	–	–	[17]	AUS
* *Acacia acradenia* F. Muell. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia alexandri* Maslin [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia anceps* DC. [MIMO]	*T. miskini*	LYC	[29]	AUS
A28. *Acacia aulacocarpa* A. Cunn. ex Benth. [MIMO]	–	–	[6, 7]	AUS
B16. *Acacia auriculiformis* A. Cunn. ex Benth.	–	–	[17]	AUS
* *A. auriculiformis* A. Cunn. ex Benth. [MIMO]	*T. miskini*	LYC	[29]	AUS
	–	–	[17]	AUS
* *Acacia crassicarpa* A. Cunn. ex Benth. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia flavescens* A. Cunn. ex Benth. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia harpophylla* F. Muell. ex Benth. [MIMO]	*T. miskini*	LYC	[29]	AUS
A29. *Acacia hemignosta* A. Cunn. ex Benth. [MIMO]	–	–	[6, 7]	AUS
* A30. *Acacia holosericea* A. Cunn. ex G. Don [MIMO]	*T. miskini*	LYC	[29]	AUS
	–	–	[6, 7]	AUS
B17. *Acacia mangium* Willd. [MIMO]	*T. miskini*	LYC	[29]	AUS
	–		[6, 7]	AUS
* *Acacia neriifolia* A. Cunn. ex Benth. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia polystachya* A. Cunn. ex Benth. [MIMO]	*Anthene lycaenoides* C. Felder	LYC	[29]	AUS
* *Acacia pycnantha* Benth. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia salicina* Lindl. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia saligna* (Labill.) H. L. Wendl. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia tetragonophylla* F. Muell. [MIMO]	*T. miskini*	LYC	[29]	AUS
* *Acacia victoriae* Benth. [MIMO]	*T. miskini*	LYC	[29]	AUS
B18. *Bauhinia monandra* Kurz [LEGU]	*Pseudococcus lilacinus* Cockerell	PSE	[48]	PHL
* *Caesalpinia bonduc* (L.) Roxb. [CAES]	*A. lycaenoides*	LYC	[29]	AUS
* *Caesalpinia crista* L. [CAES]	*A. lycaenoides*	LYC	[29]	AUS
* *Caesalpinia mexicana* A. Gray [CAES]	*A. lycaenoides*	LYC	[29]	AUS
A31. *Caesalpinia pulcherrima* (L.) Sw. [CAES]	–		[6, 7]	AUS
B19. *Caesalpinia traceyi* L. Pedley [CAES]	*Coccus* sp.	COC	[8]	AUS
	Sextius cf. '*kurandae*'	MEM	[8]	AUS

*	*Cajanus reticulatus* (Aiton) F. Muell.	*T. miskini*	LYC	[29]	AUS
*	*Calliandra houstoniana* (Mill.) Standl. [MIMO]	*A. lycaenoides*	LYC	[29]	AUS
*	*Calliandra surinamensis* Benth. [MIMO]	*A. lycaenoides*	LYC	[29]	AUS
	A32. *Canavalia rosea* (Sw.) DC. [*Canavalia maritima*]	–		[17]	AUS
	B20. *Cassia auriculata* L. [CAES]	*Z. chrysomallus*	LYC	[28]	LKA
*		*A. lycaenoides*	LYC	[29]	AUS
*	B21. *Cassia fistula* L.	*Anthene lycaenoides godeffroyi* (Semper)	LYC	[49]	AUS
	C. fistula L. [CAES]	*H. phorbas*	LYC	[29]	AUS
*		*A. lycaenoides*	LYC	[29]	AUS
*		*Anthene seltuttus* Röber	LYC	[49]	AUS
	B22. *Castanospermum australe* A. Cunn. & C. Fraser ex Hook.	*H. phorbas*	LYC	[29]	AUS
*	*Cathormion umbellatum* (Vahl) Kosterm.	*T. miskini*	LYC	[29]	AUS
	B23. *Dalbergia sissoo* Roxb. ex DC.	*Coccus hesperidum* L. [*Lecanium hesperidum*]	COC	[30]	IND
		Hilda bengalensis	TET	[30]	IND
		Icerya sp.	MAR	[30]	IND
		Oxyrhachis tarandus F.	MEM	[30]	IND
	D4. *Delonix regia* (Bojer ex Hook.) Raf. [CAES]	*A. seltutus*	LYC	[29]	AUS
*	*Dendrolobium umbellatum* (L.) Benth.	*A. lycaenoides*	LYC	[29]	AUS
	B24. *Entada phaseoloides* Merrill [MIMO]	*Coccus* sp.	COC	[8]	AUS
		Planococcus citri (Risso)	PSE	[8]	AUS
		Sextius cf. '*kurandae*'	MEM	[8]	AUS
	A33. *Erythrophleum chlorostachys* (F. Muell.) Baill. [CAES]	–	–	[6, 7]	AUS
	B25. *Inocarpus fagifer* (Parkinson) Fosberg [*Inocarpus edulis*]	*M. malaitensis*, *Paraputo leveri* (Green) (comb. nov.)	PSE	[40]	SLB
	B26. *Millettia pinnata* (L.) Panigrahi	*A. seltutus*	LYC	[29]	AUS
*		*A. lycaenoides*	LYC	[29]	AUS
	M. pinnata (L.) Panigrahi [*Pongamia pinnata]*	–	–	[32]	AUS
*	*Paraserianthes lophanta* (Willd.) I.C. Nielsen [MIMO]	*T. miskini*	LYC	[29]	AUS
	B27. *Pueraria phaseoloides* (Roxb.) Bth.	*Catochrysops panormus* Felder	LYC	[50]	THA
		Rapala pheretima Hewitson	LYC	[50]	THA
	B28. *Saraca thaipingensis* Cantley ex Prain	*A. seltutus*	LYC	[29]	AUS
	S. thaipingensis Cantley ex Prain [CAES]	*A. emolus goberus*	LYC	[43]	MYS
	B29. *Schotia brachypetala* Sond.	*A. seltutus*	LYC	[29]	AUS
	B30. *Senna alata* (L.) Roxb.	*H. phorbas*	LYC	[29]	AUS
*		*A. lycaenoides*	LYC	[29]	AUS
*	*Senna auriculata* (L.) Roxb.	*A. lycaenoides*	LYC	[29]	AUS
*	*Senna gaudichaudii* (Hook. & Arn.) H.S. Irwin & Barneby [*Senna retusa*]	*A. lycaenoides*	LYC	[29]	AUS
*	*Senna surattensis* (Burm. f.) H.S. Irwin & Barneby	*A. lycaenoides*	LYC	[29]	AUS
*	*Sesbania cannabina* (Retz.) Pers.	*T. miskini*	LYC	[29]	AUS
*	*Sesbania javanica* Miq. [*Sesbania javanicus*]	*T. miskini*	LYC	[29]	AUS
*	*Sesbania* sp.	*T. miskini*	LYC	[29]	AUS
19. Flagellariaceae					
	B31. *Flagellaria indica* Linn.	*H. phorbas*	LYC	[29]	AUS
		Scale insect sp.	COC+	[8]	AUS
*		*A. lycaenoides*	LYC	[29]	AUS
20. Lamiaceae					
	B32. *Clerodendrum floribundum* (R. Br.) [VERB]	*H. phorbas*	LYC	[29]	AUS
	B33. *Clerodendrum inerme* (L.) Gaertn. [VERB]	*H. phorbas*	LYC	[29]	AUS

Table 1 (Continued)

Host plant species[1]	Associated trophobiont	Fam[2]	References	Ctry[3]
* *Clerodendrum* sp. [VERB]	*A. lycaenoides*	LYC	[29]	AUS
* *Clerodendrum sublimis*	*Austrotartessus* spp.	MEM	[16]	AUS
* *Clerodendrum tracyanum* (F. Muell.) F. Muell. Ex Benth	–	–	[16]	AUS
B34. *Faradaya splendida* F. Muell. [VERB]	*A. micale*, *H. phorbas*	LYC	[29]	AUS
*	*A. lycaenoides*	LYC	[29]	AUS
A34. *Premna integrifolia* L.	–	–	[13]	VNM
D5. *Tectona grandis* L. f.	–	–	[30]	IND
T. grandis L. f. [VERB]	*P. lilacinus*	PSE	[48]	PHL
A35. *Vitex acuminata* R. Br.	–	–	[17]	AUS
21. Lauraceae				
B35. *Cryptocarya hypospodia* F. Muell.	*A. seltutus*, *A. micale*	LYC	[29]	AUS
	Toxoptera aurantii (Boyer de Fonscolombe)	APH	[8]	AUS
	Unidentified immatures	COC	[8]	AUS
* *Cryptocarya murrayi* F. Muell.	–		[16]	AUS
B36. *Endiandra microneura* C.T. White	*A. centaurus* group	LYC	[8]	AUS
	Coccus sp., *Milviscutulus* sp.	COC	[8]	AUS
	T. aurantii	APH	[8]	AUS
	Unidentified	ERI	[8]	AUS
B37. *Endiandra* cf. *monothyra* B.P.M. Hyland	*Coccus* sp., *Milviscutulus* sp.	COC	[8]	AUS
	Not collected	LYC	[8]	AUS
	Sextius cf. '*kurandae*'	MEM	[8]	AUS
A36. *Litsea glutinosa* (Lour.) C.B. Rob.	–	–	[17]	AUS
C3. *Persea americana* Mill.	–	–	[6, 7]	AUS
22. Lecythidaceae				
B38. *Planchonia careya* (F. Muell.) R. Knuth	*H. phorbas*	LYC	[6, 7]	AUS
23. Loganiaceae				
A37. *Strychnos lucida* R. Br.	–	–	[17]	AUS
24. Loranthaceae				
B39. *Dendrophthoe vitellina* (F. Muell.) Tiegh.	*A. centaurus*, *H. phorbas*	LYC	[29]	AUS
Loranthus sp.	*P. citri* [*Dactylopius citri* (*Pseudococcus citri*)]	PSE	[51]	IDN
	Saissetia coffeae (Walker) [*Lecanium hemisphaericum* (*Saissetia hemisphaericum*)]	COC	[51]	IDN
	Z. chrysomallus	LYC	[28]	LKA
25. Lythraceae				
B40. *Lagerstroemia speciosa* (L.) Pers.	*A. seltutus*, *A. centaurus*, *A. micale*	LYC	[29]	AUS
A38. *Sonneratia caseolaris* (L.) Engl.	Coccid sp.	COC	[52]	MYS
Malpighiaceae				
* *Rhyssopterys timoriensis* (DC.) Blume ex A.H.L. Jussieu [*Rhyssopterys timorensis*]	*A. lycaenoides*	LYC	[29]	AUS
26. Malvaceae				
A39. *Argyrodendron peralatum* (F.M. Bailey) Edlin ex J.H. Boas [STER]	–	–	[8]	AUS
A40. *Bombax ceiba* L.	–	–	[17]	AUS
B41. *Brachychiton acerifolius* (A. Cunn. ex G. Don) Macarthur [STER]	*A. seltutus*	LYC	[29]	AUS
A41. *Ceiba pentandra* (L.) Gaertn.	–	–	[13]	VNM

B42. *Heritiera littoralis* Aiton [STER]	*A. micale*	LYC	[29]	AUS
A42. *Sterculia quadrifida* R. Br.	–	–	[17]	AUS
B43. *Taliparitiliaceum* (L.) Fryxell [*Hibiscus tiliaceus*]	*A. madytus*, *A. micale*	LYC	[29]	AUS
	–	–	[53]	SGP
D6. *Theobroma cacao* L. [STER]	*M. malaitensis*, *P. citri*	PSE	[40]	SLB
	P. lilacinus	PSE	[5]	MYS
	Tricentrus sp.	MEM	[5]	MYS
Melastomataceae				
* *Memecylon umbellatum* Kostel	*Rachisphora* sp.	ALE	[54]	IND
27. Meliaceae				
* *Dysoxylum mollissimum* subsp. *molle* (Miq.) D.J. Mabberley	–	–	[16]	AUS
* *Dysoxylum papuanum* Mabb.	–	–	[16]	AUS
* *Dysoxylum pettigrewianum* F.M. Bailey	–	–	[16]	AUS
A43. *Khaya ivorensis* A. Chevalier	–	–	[55]	MYS
* *Toona ciliata* M. Roem	–	–	[16]	AUS
A44. *Vavaea australiana* S.T. Blake	–	–	[17]	AUS
B44. *Xylocarpus moluccensis* (Lam.) M. Roem.	*A. micale*	LYC	[29]	AUS
Xylocarpus sp.	Coccid sp.	COC	[52]	MYS
28. Menispermaceae				
* *Pachygone longifolia* F.M.Bailey	–	–	[16]	AUS
A45. *Pachygone ovata* (Poir.) Hook. f. & Thomson	–	–	[17]	AUS
A46. *Stephania japonica* Miers	Scale insect sp.	COC+	[8]	AUS
29. Moraceae				
C4. *Artocarpus heterophyllus* Lam.	–	–	[35]	MYS
A47. *Ficus madurensis* Miq.	–	–	[43]	MYS
A48. *Ficus opposita* Miq.	–	–	[6, 7]	AUS
A49. *Ficus pantoniana* King	*Icerya* sp.	MAR	[8]	AUS
B45. *Ficus religiosa* L.	*C. hesperidum* [*L. hesperidum*]	COC	[30]	IND
	H. bengalensis	TET	[30]	IND
	Icerya sp.	MAR	[30]	IND
	O. tarandus F.	MEM	[30]	IND
B46. *Ficus septica* Burm. f.	*L. painei*	PSE	[40]	SLB
Ficus sp.	*L. painei*	PSE	[40]	SLB
	Scale insect sp.	COC+	[45]	AUS
A50. *Malaisia scandens* (Lour.) Planch.	–	–	[17]	AUS
30. Myristicaceae				
B47. *Myristica insipida* R. Br.	*Milviscutulus* sp.	COC	[8]	AUS
	Sextius cf. '*kurandae*'	MEM	[8]	AUS
31. Myrsinaceae				
B48. *Aegiceras corniculatum* (L.) Blanco	*H. phorbas*	LYC	[29]	AUS
* *Ardisia pachyrrachis* (F.Muell.) F.M. Bailey	–	–	[16]	AUS
* *Embelia caulialata* S.T.Reynolds	–	–	[16]	AUS
32. Myrtaceae				
A51. *Acmena graveolens* L.S. Smith	*Milviscutulus* sp.	COC	[8]	AUS
Acmena sp.	*A. micale*	LYC	[29]	AUS
	H. phorbas	LYC	[29]	AUS
B49. *Corymbia intermedia* (R.T. Baker) K.D. Hill & L.A.S. Johnson	*A. centaurus*	LYC	[29]	AUS
	Narathura araxes eupolis (Miskin)	LYC	[56]	AUS

Table 1 (Continued)

Host plant species[1]	Associated trophobiont	Fam[2]	References	Ctry[3]
* *Corymbia polycarpa* (F. Muell.) K.D. Hill & L.A.S. Johnson	*T. miskini*	LYC	[29]	AUS
B50. *Corymbia ptychocarpa* (F. Muell.) K.D. Hill & L.A.S. Johnson	*A. centaurus*	LYC	[29]	AUS
B51. *Corymbia tessellaris* (F. Muell.) K.D. Hill & L.A.S. Johnson	*A. centaurus*	LYC	[29]	AUS
A52. *Eucalyptus alba* Reinw. ex Blume	–	–	[32]	AUS
* *Eucalyptus confertiflora* F. Muell.	*T. miskini*	LYC	[29]	AUS
* *Eucalyptus drepanophylla* F. Muell. ex Benth.	*T. miskini*	LYC	[29]	AUS
A53. *Eucalyptus foelscheana* F. Muell.	–	–	[6, 7]	AUS
A54. *Eucalyptus miniata* A. Cunn. ex Schauer	–	–	[6, 7]	AUS
A55. *Eucalyptus papuana* F. Muell.	–	–	[32]	AUS
Eucalyptus sp.	*A. centaurus*	LYC	[29]	AUS
*	*T. miskini*	LYC	[29]	AUS
A56. *Eucalyptus tectifica* F. Muell.	–	–	[6, 7]	AUS
A57. *Eucalyptus tereticornis* Sm.	–	–	[13]	VNM
A58. *Eucalyptus tetrodonta* F. Muell.	–	–	[6, 7]	AUS
* *Eucalyptus torelliana* F. Muell.	*T. miskini*	LYC	[29]	AUS
A59. *Lophostemon lactifluus* (F. Muell.) Peter G. Wilson & J.T. Waterh.	–	–	[6, 7]	AUS
A60. *Lophostemon suaveolens* (Sol. ex Gaertn.) Peter G. Wilson & J.T. Waterh. [*Tristania suaveolens*]	–	–	[32]	AUS
A61. *Melaleuca leucadendra* (L.) L.	–	–	[6, 7]	AUS
B52. *Melaleuca quinquenervia* (Cav.) S.T. Blake	*A. centaurus*	LYC	[29]	AUS
	N. araxes eupolis	LYC	[56]	AUS
A62. *Melaleuca viridiflora* Sol. ex Gaertn.	–	–	[6, 7]	AUS
D7. *Psidium guajava* L.	*P. lilacinus*	PSE	[48]	PHL
	Z. chrysomallus	LYC	[28]	LKA
	–	–	[57]	MYS
B53. *Ristantia pachysperma* (Bailey) Peter G. Wilson & J.T. Waterh.	*A. micale*	LYC	[29]	AUS
B54. *Syzygium cormiflorum* B.P.M. Hyland	*A. micale*	LYC	[29]	AUS
	Coccus sp., *Milviscutulus* sp.	COC	[8]	AUS
* C5. *Syzygium cumini* (L.) Skeels	*Rachisphora* sp.	ALE	[54]	IND
	–	–	[58]	LKA
	–	–	[30]	IND
* A63. *Syzygium* '*erythrocalyx*' B. Hyland	–	–	[16]	AUS
Syzygium sp.aff. *erythrocalyx*	*A. micale*	LYC	[29]	AUS
A64. *Syzygium eucalyptoides* (F. Muell.) B. Hyland	–	–	[6, 7]	AUS
C6. *Syzygium jambos* (L.) Alston	–	–	[59]	THA
A65. *Syzygium megacarpum* (Craib) N.C. Rathakrishnan & N.C. Nair	–	–	[59]	THA
A66. *Syzygium samarangense* (Blume) Merr. & L.M. Perry	–	–	[59]	THA
A67. *Syzygium sayeri* B.P.M. Hyland	Coccid sp.	COC+	[8]	AUS
A68. *Syzygium suborbiculare* (Benth.) T.G. Hartley & L.M. Perry	–	–	[6, 7]	AUS
B55. *Syzygium tierneyanum* (Benth.) T.G. Hartley & L.M. Perry	*A. micale*	LYC	[29]	AUS
B56. *Syzygium wilsoni* (F. Muell.) B. Hyland	*A. seltutus*, *H. phorbas*	LYC	[29]	AUS
A69. *Xanthostemon paradoxus* F. Muell.	–	–	[6, 7]	AUS
Oleaceae				
* *Jasminum didymum* G. Forst	–	–	[16]	AUS

33. Pandanaceae					
A70. *Pandanus spiralis* R. Br.	–		–	[6, 7]	AUS
34. Passifloraceae					
A71. *Adenia heterophylla* (Blume) Koord.	–		–	[17]	AUS
35. Phyllantaceae					
A72. *Breynia stipitata* Mull. Arg.	–		–	[17]	AUS
* *Bridelia tomentosa* Blume [*Briedelia tomentosa*] [EUPH]	*A. lycaenoides*		LYC	[29]	AUS
B57. *Glochidion ferdinandi* (Mull. Arg.) F.M. Bailey [EUPH]	*A. micale*		LYC	[29]	AUS
* *Glochidion philippicum* (Cav.) C.B.Rob. [EUPH]	–		–	[16]	AUS
36. Proteaceae					
A73. *Cardwellia sublimis* F. Muell.	*Austrotartessus* sp.		CIC	[8]	AUS
	Coccus sp.		COC	[8]	AUS
* *Macadamia integrifolia* Maiden & Betche	*N. berenice*		LYC	[29]	AUS
* *Macadamia tetraphylla* L.A.S. Johnson	*N. berenice*		LYC	[29]	AUS
A74. *Persoonia falcata* R. Br.	–		–	[6, 7]	AUS
37. Putranjivaceae					
A75. *Drypetes lasiogyna* (F. Muell.) Pax & K. Hoffm.	–		–	[17]	AUS
38. Rhamnaceae					
A76. *Ziziphus oenoplia* (L.) Mill.	–		–	[17]	AUS
39. Rhizophoraceae					
Bruguiera sp.	Coccid sp.		COC	[52]	MYS
B58. *Ceriops tagal* (Perr.) C.B. Robb	*H. phorbas*		LYC	[29]	AUS
Ceriops sp.	Coccid sp.		COC	[52]	MYS
C7. *Rhizophora mucronata* (Lam.)	–		–	[9]	THA
40. Rubiaceae					
A77. *Aidia cochinchinensis* Lour. [*Randia cochinchinensis*]	–		–	[17]	AUS
D8. *Coffea excelsa* A. Chevalier	*Coccus viridis* Green		COC	[61]	MYS
D9. *Coffea robusta* L. Linden	*C. viridis*		COC	[61]	MYS
Coffea sp.	*C. viridis*		COC	[60]	IND
	C. viridis [*Lecanium viridis* Green]		COC	[27]	MYS
A78. *Ixora klanderiana* F. Muell. [*Ixora klanderana*]	–		–	[17]	AUS
* *Ixora pavetta* Andrews	*Rachisphora* sp.		ALE	[54]	IND
A79. *Morinda citrifolia* L. [COMB]	–		–	[53]	SGP
A80. *Timonius timon* (Spreng.) Merr.	–		–	[17]	AUS
Uncaria sp.	–		–	[43]	MYS
41. Rutaceae					
B59. *Citrus aurantiifolia* (Christm.) Swingle [*Citrus acida*]	*C. viridis*		COC	[43]	MYS
A81. *Citrus limon* (L.) Burm. f.	–		–	[3]	CHN
A82. *Citrus maxima* (Burm.) Merr.	–		–	[3]	CHN
A83. *Citrus reticulata* Blanco	Coccid sp.		COC	[3]	CHN
	Mealybug sp.		PSE	[3]	CHN
	–		–	[33]	VNM
	Mealybug sp.		PSE	[62]	VNM
	Scale insect sp.		COC+	[62]	VNM

Table 1 (Continued)

Host plant species[1]	Associated trophobiont	Fam[2]	References	Ctry[3]
A84. *Citrus sinensis* (L.) Osbeck	–	–	[33]	VNM
	Mealybug sp.	PSE	[62]	VNM
	Scale insect sp.	COC+	[62]	VNM
Citrus sp.	–	–	[30]	IND
	–	–	[63]	SLB
	–	–	[5]	MYS
A85. *Glycosmis trifoliata* (Blume) Spreng.	–	–	[17]	AUS
A86. *Micromelum minutum* (G. Forst.) Seem.	–	–	[17]	AUS
Murraya paniculata (L.) Jack	–	–	[10]	VNM
Salicaceae				
Flacourtia sp. [FLAC]	*S. coffeae* [*L. hemisphaericum* (*S. hemisphaericum*)]	COC	[51]	IDN
42. Santalaceae				
A87. *Exocarpos latifolius* R. Br.	–	–	[17]	AUS
43. Sapindaceae				
* *Alectryon coriaceus* (Benth.) Radlk.	*N. berenice*	LYC	[29]	AUS
* *Alectryon diversifolius* (F. Muell.) S.T. Reynolds [*Heterodendron diversifolium*]	*N. berenice*	LYC	[29]	AUS
* *Arytera divaricata* F. Muell.	*N. berenice*	LYC	[29]	AUS
B60. *Arytera pauciflora* S.T. Reynolds	*A. seltutus*	LYC	[29]	AUS
*	*N. berenice*	LYC	[29]	AUS
* *Atalaya hemiglauca* (F. Muell.) F. Muell. ex Benth.	*T. miskini*	LYC	[29]	AUS
* *Atalaya salicifolia* (A.DC.) Blume	*N. berenice*	LYC	[29]	AUS
* *Atalaya variifolia* (F. Muell.) Benth.	*T. miskini*	LYC	[29]	AUS
B61. *Cupaniopsis anacardioides* (A. Rich.) Radlk.	*A. seltutus*, *A. micale*, *H. phorbas*	LYC	[29]	AUS
*	*A. lycaenoides*, *N. berenice*	LYC	[29]	AUS
Cupaniopsis sp.	*A. centaurus*	LYC	[29]	AUS
* A88. *Litchi chinensis* Sonn.	*A. lycaenoides*	LYC	[29]	AUS
	–	–	[30]	IND
	–	–	[44]	AUS
C8. *Nephelium lappaceum* L.	–	–	[64]	AUS
	–	–	[65]	IDN
B62. *Synima cordierii* Radlk.	*A. seltutus*	LYC	[8]	AUS
44. Sapotaceae				
B63. *Madhuca longifolia* (L.) J.F. Macbr. [*Bassia latifolia*]	*C. viridis*	COC	[61]	MYS
B64. *Manilkara jaimiqui* (C. Wright) Dubard subsp. *emarginata* (L.) Cronquist [*Achras sapota*]	*C. viridis*	COC	[61]	MYS
A89. *Pouteria sericea* (Aiton) Baehni	–	–	[17]	AUS
45. Smilacaceae				
B65. *Smilax australis* R. Br.	*H. phorbas*	LYC	[29]	AUS
* *Smilax* cf. *australis*	–	–	[16]	AUS
46. Theaceae				
B66. *Camellia sinensis* (L.) Kuntze	*Coccus discrepans* Green, *C. hesperidum*	COC	[66]	IND
	Metaceronema japonica (Maskell) [*Eriochiton theae* Green]	COC [ERI]	[66]	IND

47. Verbenaceae				
A90. *Citharexylum subserratum* Swartz	–	–	[6, 7]	AUS
48. Vitaceae				
A91. *Cissus adnata* Roxb.	–	–	[17]	AUS
A92. *Cissus cordata* Roxb.	–	–	[17]	AUS
Zingiberaceae				
Achasma sp.	–	–	[43]	MYS

[1]Host plants with ant nesting; *ant presence on plants without specific mention of nesting indicated possible host plants. Groups: A and B, *O. smaragdina* host plants without and with trophobionts identified to species, respectively; C and D, *Oecophylla* spp. host plants without and with trophobionts identified to species, respectively (Figure 1). Plant family name abbreviations after Kiger and Reveal [26]. Numbering of host plant families only for plants identified to species in each family.
[2]Families: ALE, Aleyrodidae; APH, Aphididae; CIC, Cicadellidae; COC, Coccidae; ERI, Eriococcidae; LYC, Lycaenidae; MAR, Margarodidae; MEM, Membracidae; PSE, Pseudococcidae; TET, Tettigometridae. Superfamily: COC+, Coccoidea.
[3]Country: AUS, Australia; BEN, Benin; CHN, China; IND, India; IDN, Indonesia; MYS, Malaysia; PHL, Philippines; SGP, Singapore; SLB, Solomon Islands; LKA, Sri Lanka; THA, Thailand; VNM, Vietnam.
[4]Paul van Mele (personal communication).

plant species with which existing perennial cropping systems could be enriched.

Materials and Methods

A survey of the literature was carried out to identify host plants and trophobionts recorded worldwide for *O. smaragdina and O. longinoda*. The literature survey was largely conducted on the CAB Direct database that included international archives dating back to 1900. The search terms '*Oecophylla longinoda*' and '*Oecophylla smaragdina*' were used to obtain records for the two species. For the purpose of this survey, 'host plants' were those that the ant was reported to nest in, while 'possible host plants' had no confirmation of nesting. Where the abstract alluded to a possible host plant, the original article was reviewed, and where more than one reference was available for a host plant, the earliest mention was recorded, along with associated trophobionts (if any) and country of occurrence.

The plant names were checked against other standardized databases using the GRIN (Online) Taxonomic Nomenclature Checker (TNC) [18]. At the date of accession (30 September 2006), the database contained over 18 000 generic and 65 000 specific or infraspecific records of vascular plants and included all currently accepted generic names (over 14 000). As representation of species in this database was incomplete, especially for non-agricultural plants, some of the plant names were checked against other sources [19–23]. The TNC highlighted species that did not match those in the database and provided up to five possible alternatives, based on which possible spelling mistakes in the original article could be corrected if a close match was found with a matching distributional range and family. Relevant articles cited by the ones found in the database search also provided additional host plant records. Scale insect trophobiont names were checked against the ScaleNet [24] database for scale insects of the world.

Statistical Analyses

Chi-square analyses of data of the host plants and associated trophobionts of *O. longinoda* and *O. smaragdina* were carried out using the statistical software Minitab 14® [25]. The two ant species were compared in the distribution of host plant species by trophobiont taxon.

Results

The CAB Direct database search for '*Oecophylla longinoda*' and '*Oecophylla smaragdina*' returned 99 and 228 records, respectively. The literature survey showed that *O. smaragdina* was recorded on 175 plant species in 46 families, with 28 associated trophobiont species in 7 families (Table 1), whereas *O. longinoda* was recorded on 66 plant

Table 2 Records of *Oecophylla longinoda* host plants and associated trophobionts from a survey of the literature (1900–2006). Records are from Way [4] in Zanzibar unless indicated otherwise in curly brackets {}. Currently accepted species and family names are used followed by names given in the original article in square brackets [ ], where different

Host plant species[1]	Associated trophobiont	Fam[2]
1. Anacardiaceae		
F1. *Anacardium occidentale* L.	*Coccus* sp. nr. *hesperidum* L., *Parasaissetia nigra* (Neitn.) [*Saissetia. nigra* (Nietn.)], *Saissetia zanzibarensis* Williams	COC
	Pseudococcus sp.	PSE
D1. *Mangifera indica* L.	*Coccus hesperidum* L., *Saissetia* sp. nr. *nigra* (Nietn.), *S. zanzibarensis*	COC
	Pseudococcus sp., *Rastrococcus iceryoides* (Green) [*Phenacoccus iceryoides* Green]	PSE
2. Annonaceae		
D2. *Annona muricata* L.	*Parasaissetia* sp. nr. *nigra* [*Saissetia* sp. nr. *nigra*]	COC
	Parastictococcus anonae (Green and Laing) [*Stictococcus anonae* Green and Laing]	STI
F2. *Annona senegalensis* Pers.	*Isthmia* sp.	TET
[*Annona chrysophylla*]	*P. nigra* [*Saissetia* sp. ?*nigra*]	COC
F3. *Canangium odoratum* (Lam.) Baill. ex King	*P. anonae* [*S. anonae*]	STI
3. Apocynaceae		
F4. *Rauvolfia mombasiana* Stapf [*Rauwolfia mombasiana*]	*Coccus viridis* Green, *Saissetia* sp. nr. *coffeae* (Wlk.), *Udinia* sp. nr. *catori* (Green) [*Saissetia* sp. nr. *catori* (Green)]	COC
	Pseudococcus sp.	PSE
F5. *Schizozygia coffaeoides* Baill.	Membracid sp.	MEM
[*Schizozygia coffeoides*]	*R. iceryoides* [*P. iceryoides*]	PSE
4. Arecaceae		
D3. *Areca catechu* L. [PALM]	*S. zanzibarensis*	COC
D4. *Cocos nucifera* L. [PALM]	*Cerataphis lataniae* Boisduval	APH
	C. hesperidum, *P. nigra* [*S. nigra*], *S. zanzibarensis*	COC
	Planococcus sp., *Pseudococcus cryptus* Hempel [*Pseudococcus citriculus* Green]	PSE
Asteraceae		
Ageratum sp. [Compositae]	*Parasaissetia* sp. nr. *nigra* [*Saissetia* sp. nr. *nigra*]	COC
	Pseudococcus sp.	PSE
5. Bignoniaceae		
F6. *Millingtonia hortensis* L. f.	*Udinia* sp. nr. *catori* [*Saissetia* sp. nr. *catori*]	COC
6. Boraginaceae		
E1. *Cordia aurantiaca* Baker [*Cordia aurentiaca*] {[67], Cameroon}	–	–
7. Burseraceae		
F7. *Canarium commune* L.	Membracid sp.	MEM
	S. zanzibarensis	COC
8. Colchicaceae		
F8. *Gloriosa simplex* Linn. [Liliaceae]	*S. zanzibarensis*	COC
9. Combretaceae		
C1. *Terminalia catappa* L.	Membracid sp.	MEM
	Saissetia sp.	COC
10. Cucurbitaceae		
F9. *Momordica foetida* Schumach.	*Saissetia* sp. nr. *coffeae*	COC
11. Euphorbiaceae		
E2. *Alchornea laxiflora* (Benth.) Pax & K. Hoffm. {[69], Kenya}	–	–
Codiaeum sp.	*Pseudococcus* sp.	PSE
12. Fabaceae		
F10. *Acacia glauca* (L.) Moench [*Leucaena glauca*] [LEGU]	*C. hesperidum*	COC
E3. *Afzelia quanzensis* Welw. [CAES] {[68], Kenya}	–	–
F11. *Bauhinia thonningii* Schumach. [LEGU]	*C. hesperidum*	COC
	Membracid sp.	MEM
	S. zanzibarensis	COC
Cassia sp. [LEGU]	Membracid sp.	MEM
	S. zanzibarensis	COC
D5. *Delonix regia* (Bojer ex Hook.) Raf. [LEGU]	*P. nigra* [*S. nigra*]	COC
F12. *Gliricidia sepium* (Jacq.) Kunth ex Walp. [LEGU]	*R. iceryoides* [*P. iceryoides*]	PSE
	S. zanzibarensis	COC

Table 2 (Continued)

Host plant species[1]	Associated trophobiont	Fam[2]
E4. *Julbernardia magnistipulata* [CAES] ([68], Kenya)	–	–
E5. *Pithecellobium dulce* (Roxb) Benth. [*Pithecollobium dulce*] [LEGU]	Membracid sp.	MEM
F13. *Tephrosia vogelii* Hook. f. [LEGU]	*C. hesperidum*	COC
13. Hypericaceae		
F14. *Harungana madagascariensis* Lam. ex Poir.	*C. viridis*, *Parasaissetia* sp. nr. *nigra* [*Saissetia* sp. nr. *nigra*], *S. zanzibarensis*	COC
	Pseudococcus sp.	PSE
	Xiphistes sp.	MEM
E6. *Vismia orientalis* Engl. {[68], Kenya}	–	–
14. Icacinaceae		
E7. *Apodytes dimidiata* E. Mey. ex Bernh. {[68], Kenya}	–	–
15. Lamiaceae		
F15. *Clerodendrum glabrum* E. May [*Clerodendron glabrum*, VERB]	*S. zanzibarensis*	COC
D6. *Tectona grandis* L. f. [VERB]	*C. hesperidum*	COC
	Membracid sp.	MEM
F16. *Vitex doniana* Sweet [VERB]	*C. hesperidum*, *Saissetia* sp. nr. *coffeae*	COC
16. Lauraceae		
F17. *Cassytha filiformis* L.	*Saissetia* sp. nr. *oleae* (Olivier) [*Saissetia* sp. nr. *oleae* (Bern.)]	COC
D7. *Persea americana* Mill.	*C. hesperidum*, *S. zanzibarensis*	COC
17. Lecythidaceae		
F18. *Barringtonia racemosa* (L.) Spreng.	*Parasaissetia* sp. nr. *nigra* [*Saissetia* sp. nr. *nigra*], *Parthenolecanium* sp. nr. *persicae* (Fabricius) [*Coccus* sp. nr. *elongatus* (Sign.)]	COC
	Membracid sp.	MEM
18. Loranthaceae		
E8. *Loranthus sansibarensis* Engl.	*Saissetia* sp.	COC
19. Lythraceae		
F19. *Sonneratia alba* Sm. (*Sonneratia caseolaris*) [SONN]	*P. nigra* [*S. nigra*], *Saissetia* sp. nr. *oleae* (Olivier) [*Saissetia* sp. nr. *oleae* (Bern.)]	COC
20. Malvaceae		
F20. *Adansonia digitata* L. [BOMB]	Margarodid sp.	MAR
	Parthenolecanium sp. nr. *persicae* [*Coccus* sp. nr. *elongatus*], *S. zanzibarensis, Udinia* sp. nr. *catori* [*Saissetia* sp. nr. *catori*]	COC
F21. *Durio zibethinus* L. [BOMB]	*Parthenolecanium* sp. nr. *persicae* [*Coccus* sp. nr. *elongatus*], *Udinia* sp. nr. *catori* [*Saissetia* sp. nr. *catori*]	COC
F22. *Grewia glandulosa* Vahl [TILI]	Margarodid sp.	MAR
	R. iceryoides [*P. iceryoides*]	PSE
E9. *Malvaviscus grandiflorus* H.B. & K	Coccid sp.	COC
D8. *Theobroma cacao* L. [STER]	*Pseudococcus* sp., *R. iceryoides* [*P. iceryoides* (*Phenacoccus iceryoides* Green)]	PSE
	Toxoptera sp. *? aurantii* (Boy)	APH
T. cacao L. ([69], Cote D'Ivoire)	Stictococcid sp.	STI
Meliaceae		
Turraea sp. {[68], Kenya}	–	–
21. Moraceae		
D9. *Artocarpus heterophyllus* Lam.	*C. hesperidum*	COC
Ficus spp.	Margarodid sp.	MAR
	P. nigra [*S. nigra*], *S. zanzibarensis*	COC
	R. iceryoides [*P. iceryoides*]	PSE
22. Myrtaceae		
F23. *Eucalyptus camaldulensis* Dehnh.	*Coccus* sp. *?hesperidum*, *C. viridis*, *S. zanzibarensis*	COC
D10. *Psidium guajava* L.	*C. viridis, S. zanzibarensis*	COC
	Pseudococcus sp.	PSE
F24. *Syzygium aromaticum* (L.) Merr. & L. M. Perry [*Jambosa caryophyllus* (*Eugenia aromatica*)]	*Coccus* sp. nr. *hesperidum*, *C. viridis*, *Eulecanium* sp., *Parasaissetia* sp. nr. *nigra* [*Saissetia* sp. nr. *nigra*], *Saissetia* sp. nr. *coffeae*, *S. zanzibarensis*	COC
D11. *Syzygium cumini* (L.) Skeels (*Eugenia jambolana*)	*Coccus* sp. nr. *viridis*, *S. zanzibarensis*	COC
	Membracid sp.	MEM

Table 2 (Continued)

Host plant species[1]	Associated trophobiont	Fam[2]
D12. *Syzygium jambos* (L.) Alston [*Jambosa jambos* (*Eugenia jambos*)]	*Coccus* sp. nr. *hesperidum*, *Eucalymnatus tessellatus* (Sign.), *S. zanzibarensis*	COC
	Membracid sp.	MEM
E10. *Syzygium malaccense* (L.) Merr. & L.M. Perry [*Jambosa malaccensis* (*Eugenia malaccensis*)]	Membracid sp.	MEM
23. Olacaceae		
E11. *Olax dissitiflora* Oliv. {[68], Kenya}	–	–
24. Oleaceae		
F25. *Jasminum fluminense* Vell.	*S. zanzibarensis*	COC
25. Oxalidaceae		
F26. *Averrhoa bilimbi* L.	Pseudococcid sp.	PSE
	S. zanzibarensis	COC
F27. *Averrhoa carambola* L.	*S. zanzibarensis*	COC
26. Passifloraceae		
F28. *Passiflora quadrangularis* L.	*P. nigra* [*S. nigra*]	COC
27. Phyllanthaceae		
F29. *Bridelia micrantha* (Hochst.) Baill. [EUPH]	Membracid sp.	MEM
	P. nigra [*S. nigra*]	COC
E12. *Uapaca alluminata* [CAES] {[67], Cameroon}	–	–
28. Rhamnaceae		
E13. *Ziziphus mauritiana* Lam.	Pseudococcid sp.	PSE
29. Rhizophoraceae		
Ceriops sp.	*P. nigra* [*S. nigra*], *S. zanzibarensis*	COC
D13. *Rhizophora mucronata* (Lam.)	*S. zanzibarensis*	COC
30. Rosaceae		
E14. *Eriobotrya japonica* (Thunb.) Lindl.	Coccid sp.	COC
31. Rubiaceae		
F30. *Canthium zanzibaricum* Klotzsch	*C. hesperidum, Parasaissetia* sp. nr. *nigra* [*Saissetia* sp. nr. *nigra*], *S. zanzibarensis*	COC
	Pseudococcus sp.	PSE
F31. *Chassalia umbraticola* Vatke	*C. viridis*	COC
D14. *Coffea excelsa* A. Chevalier	*C. viridis*, *S. zanzibarensis*	COC
F32. *Coffea liberica* Bull. ex K. Shum.	*C. viridis*, *P. nigra* [*S. nigra*], *S. zanzibarensis*	COC
D15. *Coffea robusta* L. Linden	*C. viridis*, *S. zanzibarensis*	COC
Polysphaeria sp.	*C. viridis*	COC
32. Rutaceae		
Citrus, five spp.	*C. lantaniae*	APH
	C. hesperidum, *C. viridis*, *S. zanzibarensis*	COC
	Icerya seychellarum (Westw.)	MAR
	Planococcus citri, *P. cryptus* [*P. citriculus*], *Pseudococcus* sp.	PSE
E15. *Murraya paniculata* (L.) Jack	Coccid sp.	COC
33. Sapindaceae		
D16. *Nephelium lappaceum* L.	*C. hesperidum* L., *Udinia* sp. nr. *catori* [*Saissetia* sp. nr. *catori*]	COC
	P. anonae [*S. anonae*]	STI
E16. *Paullinia pinnata* L.	*Pseudococcid* sp.	PSE
34. Sapotaceae		
F33. *Achras zapotilla* (Jacq.) Nutt.	*C. viridis, Saissetia* sp. nr. *coffeae, S. zanzibarensis*	COC

[1]Groups: C and D, *Oecophylla* spp. host plants without and with trophobionts identified to species, respectively; E and F, *O. longinoda* host plants without and with trophobionts 0identified to species, respectively (Figure 1). Plant family name abbreviations after Kiger and Reveal [26]. Numbering of host plant families only for plants identified to species in each family.
[2]Families: APH, Aphididae; COC, Coccidae; MAR, Margarodidae; MEM, Membracidae; PSE, Pseudococcidae; STI, Stictococcidae; TET, Tettigometridae.

species in 34 families with 17 associated trophobiont species in 6 families (Table 2). In addition, there were 73 species (22 families) of possible host plants (i.e. nesting not confirmed) for *O. smaragdina* (Table 1). A number of these possible host plants had been reported as host plants also, but the distinction was maintained because their associated trophobiont species were different. Trophobiont association may influence a plant species' suitability as a host plant for the weaver ant.

The large number of host plant records for *O. smaragdina* compared with *O. longinoda* was due in part to an extensive checklist of host plants of lepidopteran species

Table 3 Percentage of host plant species recorded in the literature for trophobionts tended by *Oecophylla smaragdina* and *Oecophylla longinoda*, and the distribution of trophobiont species by taxon. Number of species in parentheses

	O. smaragdina		*O. longinoda*	
Trophobiont taxon[1]	% Host plant species (*n*=127)	% Trophobiont species (*n*=41)	% Host plant species (*n*=99)	% Trophobiont species (*n*=27)
Lycaenidae	46.5	24.4	–	–
Coccoidea	41.7	56.1	82.8	81.5
Coccidae	21.6	24.4	56.6	44.4
Pseudococcidae	9.4	17.5	16.2	20.2
Margarodidae	3.1	4.9	4.0	7.4
Eriococcidae	0.8	2.4	–	–
Stictococcidae	–	–	4.0	7.4
Membracidae	7.1	9.8	11.1	7.4
Aphididae	2.4	4.9	3.0	7.4
Tettigometridae	1.6	2.4	1.0	3.7
Cicadellidae	0.8	2.4	–	–
Total	100.0	100.0	100.0	100.0

[1]Scale insect families further grouped under the superfamily Coccoidea.

in the family Lycaenidae [29]. Lycaenid larvae secrete nutritious rewards for ants [70] and several lycaenid species are obligately tended by *O. smaragdina* [29], while no lycaenids have been reported for *O. longinoda*. Lycaenid host plants consisted of as much as 46.5% of the host plant species recorded for *O. smaragdina*, but contributed only 24.4% to the total number of trophobiont species reported for the ant (Table 3). Excluding the family Lycaenidae, there was no significant difference between the two ant species, in the number of trophobiont species reported for Coccidae, Pseudococcidae, other scale insect families, and other trophobiont families (χ^2=1.000; d.f.=1, 3; *P*=0.801).

Figure 1 summarizes the number of (confirmed) host plant species and families for the two ant species, and the number of trophobiont species associated with the ant species. Trophobionts were listed on less than half of the host plants recorded for *O. smaragdina* (various references) but on most host plants recorded for *O. longinoda*, many of which were listed in Way [4]. There were 17 plant species on which both ant species were reported nesting (Table 4). Eleven of the plant species reported trophobiont associations but only *Coffea excelsa* A. Chevalier (Rubiaceae) and *Coffea robusta* L. Linden shared a common trophobiont, *Coccus viridis* Green (Coccidae) tended by both ant species. *C. viridis* is a scale insect found on many plant species around the world, including 7 [24] of the 17 plant species hosting both *Oecophylla* spp. This scale insect was reported as a coffee pest in Sri Lanka, particularly on disease-weakened plants. *C. viridis* tended by *O. smaragdina* in Malaya did not cause apparent damage to healthy coffee plants but preventive measures were taken to destroy the ants and scale insects because the ants bit coffee pickers and were perceived to spread scales [61].

Six other trophobiont species were reported for both *Oecophylla* spp. but associated with different host plants:

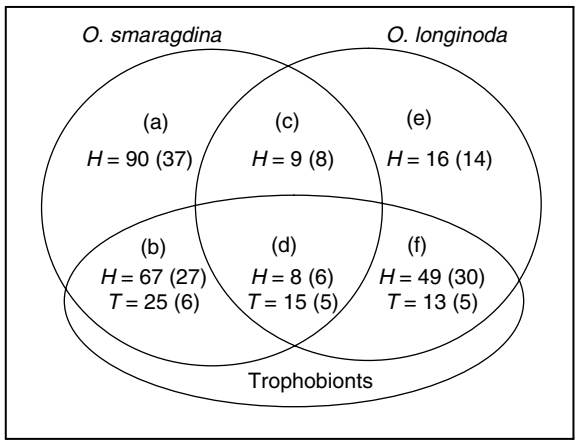

Figure 1 Number of host plant species, plant families and trophobiont species reported in the literature for *Oecophylla smaragdina* and *Oecophylla longinoda*. *H*, number of host plant species; *T*, number of trophobiont species for the host plant species. The number of families is stated in parentheses. There were 17 host plant species common to both *Oecophylla* spp. (subsets (c) and (d)). For these 17 host plant species, trophobionts were recorded on 8 and 16 plant species hosting *O. smaragdina* and *O. longinoda*, respectively (indicated by group D in Tables 1 and 2, respectively)

Planococcus citri (Risso) (Pseudococcidae), *Coccus hesperidum* L., *Saissetia coffeae* (Walker) and *Parasaissetia nigra* (Neitner) (Coccidae), *Toxoptera aurantii* (Boyer de Fonscolombe) and *Cerataphis lataniae* Boisduval (Aphididae). Except for *C. lataniae*, an ornamental pest that has a relatively small host range [71], these trophobionts are polyphagous and widely distributed [24]. *P. citri* damages a wide range of crops, some by vectoring diseases, while *C. hesperidum, S. coffeae, P. nigra* and *T. aurantii* are pests of citrus, ornamentals, litchi, and coffee and citrus, respectively. The aphids potentially vector plant viruses as well.

Table 4 Host plant species common to *Oecophylla smaragdina* and *Oecophylla longinoda* reported in a CAB database literature search (1900–2007)

Host plant species	Family	Common name
Annona muricata	Annonaceae	Soursop, anona
Areca catechu	Arecaceae	Areca
Artocarpus heterophyllus	Moraceae	Jackfruit
Cocos nucifera	Arecaceae	Coconut
Coffea excelsa	Rubiaceae	Coffee
Coffea robusta	Rubiaceae	Coffee
Delonix regia	Fabaceae	Flame tree
Mangifera indica	Anacardiaceae	Mango
Nephelium lappaceum	Sapindaceae	Rambutan
Persea americana	Lauraceae	Avocado
Psidium guajava	Myrtaceae	Guava
Rhizophora mucronata	Rhizophoraceae	Mangrove
Syzygium cumini	Myrtaceae	Java plum, jamun
Syzygium jambos	Myrtaceae	Rose apple
Tectona grandis	Lamiaceae	Teak
Terminalia catappa	Combretaceae	Tropical almond
Theobroma cacao	Malvaceae	Cocoa

O. smaragdina was a nuisance pest in tea plantations and jackfruit orchards in India [66, 72] because the ants bit workers. As in the case of *C. viridis* on coffee, hemipteran insects tended by weaver ants normally did not noticeably damage clove, tea, rubber and jackfruit [47, 66, 72, 73]. However, large populations on very young coffee plants caused some yellowing [4]. A large *O. longinoda* colony confined to a single tree was also observed to have damaging scale population levels [74]. *O. longinoda* was shown to distribute scale insects on available plants such that the plants were not affected by scale insect feeding. Further, culling of excessive scale insects by *O. longinoda* maintains trophobiont populations at a level that would meet colony honeydew needs [73]. Nevertheless, control measures were often advocated to prevent the homopterans from being spread by their custodians [47, 66, 72, 73]. In addition to being a nuisance pest, *O. smaragdina* was found to deter insect pollinators of *Nephelium lappaceum* L. (Sapindaceae) but no apparent reduction in fruit yield was observed [65]. The ant also preys on honeybees (*Apis mellifera* L., Hymenoptera) [4].

Discussion

The number of host plant species reported for *O. smaragdina* was more than double that for *O. longinoda*, suggesting a greater research interest toward the former or a wider geographic distribution with a more diverse plant community. Recent contributions to the *O. smaragdina* host plant species and trophobiont records [6–8, 29] comprized over half the records and reflect the current research interest toward this ant species. In contrast, the majority of host plant species for *O. longinoda* were reported in 1954 and was likely biased towards plants with trophobionts [4]. The interest displayed for *O. smaragdina* has largely been in the context of its application as a biological control agent where the ant is a valued tool in Asian and Australian IPM systems [75].

The present study also revealed that the 17 host plant species common to both ant species were largely fruit or cash crop species cultivated in the tropics around the world. Furthermore, about half the host plant species reported for either ant species are economically important or of value to human society. Thus, there is a large potential pool of value-added host plant species from which candidates that favour either ant species may be chosen. The applicability of the ants to protecting these plants depends on how the plants are utilized where grown. For example, in the Can Tho province, kapok (*Ceiba pentandra*) trees are either lopped for leaves used to produce incense sticks or left as is to produce kapok [76]. Weaver ants are unlikely to nest in regularly lopped kapok trees. Therefore, when selecting trees to promote certain ecosystem functions, local practices need to be considered [77].

It is apparent that the trophobiont species of *Oecophylla* spp. are not well documented yet. The two ant species appeared to associate with several trophobiont taxa, particularly those from the family Membracidae and superfamily Coccoidea. The trophobiont species common to both *Oecophylla* spp. were generally highly polyphagous and occur on a large number of plant species that host these ants [24] but have not yet been recorded as such. The pest risk of trophobionts found on these plant species may not be significant on healthy mature trees as indicated by observations on tea, coffee, rubber, jackfruit and clove noted earlier. The scarce mention and limited abundance of *O. smaragdina*-tended trophobionts on citrus crops where the ant has been used [3, 13] and the widespread use of this ant suggests that trophobionts do not pose a notable pest risk for some crops. The ants may keep their trophobiont population levels in check. It was also suggested that the *O. longinoda* preferentially tended non-pest Stictococcids rather than the pest-prone Pseudococcids [4]. However, where trophobionts may cause direct damage, e.g. when concentrated on developing fruit of cocoa [4] and mango [78], cost-benefit analyses comparing ant-treated with conventionally managed crops are needed. For example, mealybug damage was found to be greater for weaver ant-occupied mango trees compared with insecticide-sprayed trees, but overall control of pests was equally good [78].

The practical application of the weaver ants to crop protection is also dependent on human perception and acceptance. While trophobionts of the weaver ant, e.g. scales in mango, are perceived as pests or insignificant at best by western scientists [75], fruit pickers associate the presence of scales on mango as an indication of quality

fruit in Benin (Paul van Mele, personal communication). In Vietnam, which has a long-standing tradition of weaver ant application to crop protection, locals regard the ant favourably and have devised methods, e.g. harvesters apply ash to arms and hands, for harvesting fruit that minimize ant bites [10]. In Australia, mango pickers immediately immerse harvested fruit in buckets of water to remove ants and spray trees with water prior to harvesting to reduce ant activity [78]. In Malaysia however, public opinion appears divided as to the beneficial versus pest status of the weaver ant (G. T. Lim, personal observation). While acknowledging the protective effects of the ants on fruit trees, many people consider the ant a pest because it bites and makes harvesting fruit difficult.

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References

1. Hölldobler B. Territorial behavior in the green tree ant (*Oecophylla smaragdina*). Biotropica 1983;15:241–50.
2. Ledoux A. Rechercher sur la biologie de la fourmi fileuse (*Oecophylla longinoda* Latr.). Annales des sciences naturelles. Zoologie et biologie animale 1950;12:333–461.
3. Huang HT, Yang P. The ancient cultured citrus ant. BioScience 1987;37:655–71.
4. Way MJ. Studies of the life history and ecology of the ant *Oecophylla longinoda* Latreille. Bulletin of Entomological Research 1954;45:93–112.
5. Way MJ, Khoo KC. Colony dispersion and nesting habits of the ants, *Dolichoderus thoracicus* and *Oecophylla smaragdina* (Hymenoptera: Formicidae), in relation to their success as biological control agents on cocoa. Bulletin of Entomological Research 1991;81:341–50.
6. Peng RK, Christian K, Gibb K. Distribution of the green ant, *Oecophylla smaragdina* (F.) (Hymenoptera: Formicidae), in relation to native vegetation and the insect pests in cashew plantations in Australia. International Journal of Pest Management 1997;43:203–11.
7. Peng RK, Christian K, Gibb K. Control threshold analysis for the tea mosquito bug, *Helopeltis pernicialis* (Hemiptera: Miridae) and preliminary results concerning the efficiency of control by the green ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae) in northern Australia. International Journal of Pest Management 1997;43:233–7.
8. Blüthgen N, Fiedler K. Interactions between weaver ants *Oecophylla smaragdina*, homopterans, trees and lianas in an Australian rain forest canopy. Journal of Animal Ecology 2002;71:793–801.
9. Offenberg J, Havanon S, Aksornkoae S, MacIntosh DJ, Nielsen MG. Observations on the ecology of weaver ants (*Oecophylla smaragdina* Fabricius) in a Thai mangrove ecosystem and their effect on herbivory of *Rhizophora mucronata* Lam. Biotropica 2004;36:344–51.
10. Van Mele P, Cuc NTT. Ants as Friends: Improving Your Tree Crops with Weaver Ants. CABI Bioscience; 2003. p. 67. ISBN 958-97218-2-6.
11. Peng RK, Christian K, Gibb K. Implementing Ant Technology in Commercial Cashew Plantations and Continuation of Transplanted Green Ant Colony Monitoring. RIRDC, Australia; 2004. Available from: URL: http://www.rirdc.gov.au/reports/NPP/04-088.pdf (accessed 6 March 2007).
12. Peng RK, Christian K, Gibb K. The effect of colony isolation of the predacious ant, *Oecophylla smaragdina* (F.) (Hymenoptera: Formicidae), on protection of cashew plantations from insect pests. International Journal of Pest Management 1999;45:189–94.
13. Van Mele P, Cuc NTT. Evolution and status of *Oecophylla smaragdina* as a pest control agent in citrus in the Mekong Delta, Vietnam. International Journal of Pest Management 2000;46:295–301.
14. Lim GT, Kirton LG. A preliminary study on the prospects for biological control of the mahogany shoot borer, *Hypsipyla robusta* (Lepidoptera: Pyralidae), by ants (Hymenoptera: Formicidae). In: Proceedings of the International Conference on Forestry and Forest Products Research. FRIM, Malaysia; 2003. p. 240–4.
15. Van Mele P, Vaysierres JF, Tellingen EV, Vrolijks J. Effects of an African weaver ant in controlling mango fruit flies (Diptera: Tephritidae) in Benin. Journal of Economic Entomology 2007;100:695–701.
16. Blüthgen N, Stork NE, Fiedler K. Bottom-up control and co-occurrence in complex communities: honeydew and nectar determine a rainforest ant mosaic. Oikos 2004; 106:344–58.
17. Begg RJ. The effects of cyclone 'Tracy' on the ant *Oecophylla smaragdina*. Journal of the Australian Entomological Society 1977;16:289–95.
18. USDA-ARS. Taxonomic Nomenclature Checker – GRIN [online]. 2006. Available from: URL: http://pgrdoc.ipgri.cgiar.org/taxcheck/grin/index.html (accessed 30 September 2006).
19. RBG. Flora Zambesiaca. Board of Trustees of the Royal Botanic Gardens, Kew; 2004. Availabe from: URL: http://www.rbgkew.org.uk/floras/fz/intro.html (accessed 30 September 2006).
20. The International Plant Names Index (IPNI) 2004. Available from: URL: http://www.ipni.org (accessed 29 October 2006).
21. DOL. 2005. PlantSystematics.org. DiversityofLife.org, http://132.236.163.181/index.html (accessed 30 September 2006).
22. Western Australian Herbarium. FloraBase (ver 2.1.3) – The Western Australian Flora. Department of Environment and Conservation; 2006. Available from: URL: http://florabase.calm.wa.gov.au/ (accessed 30 September 2006).
23. APNI. The Australian Plant Name Index. ANBG; 2006. Available from: URL: http://www.anbg.gov.au/apni/apni.html (accessed 30 September 2006).
24. Ben-Dov Y, Miller DR, Gibson GAP. ScaleNet: Query Index. 2005. Available from: URL: http://www.sel.barc.usda.gov/scalenet/query.htm (accessed 1 November 2006).

25. MINITAB. MINITAB Statistical Software Release 14.20; 2007.

26. Kiger RW, Reveal JL. A Comprehensive Scheme for Standardized Abbreviation of Usable Plant-family Names and Type-based Suprafamilial Names. 2006. Available from: URL: http://www.chemlife.umd.edu/emeritus/reveal/pbio/fam/famabbr.html (accessed 5 May 2007).

27. Corbett GH. Division of Entomology. Annual report for the year 1936. 26, Department of Agriculture, South Seas and Federated Malay States, General Series/Department of Agriculture, Straits Settlement; 1937.

28. van der Poorten M, van der Poorten N. Butterflies and Dragonflies of Sri Lanka. 2006. Available from: URL: http://www.srilankaninsects.net/Butterflies/Lycaenidae/Redspot/RedSpot.htm (accessed 30 September 2006).

29. Braby MF. 2000. Family Lycaenidae. In: Butterflies of Australia. CSIRO Publishing, Canberra; 2000. p. 617–856.

30. Dutt GR. Life histories of Indian insects, IV (Hymenoptera): *Oecophylla smaragdina* F. Memoirs of the Department of Agriculture in India (Entomology); 1912. p. 254–60.

31. Van Mele P, Cuc NTT, Van Huis A. Farmers' knowledge, perceptions and practices in mango pest management in the Mekong Delta, Vietnam. International Journal of Pest Management 2001;47:7–16.

32. Lokkers C. The distribution of the weaver ant, *Oecophylla smaragdina* (Fabricius) (Hymenoptera: Formicidae) in Northern Australia. Australian Journal of Zoology 1986; 34:683–7.

33. Van Mele P, Cuc NTT. Predatory ants in orchards in the Mekong Delta of Vietnam. In: Loke WH, editor. Symposium on Biological Control in the Tropics. CABI, Serdang, Malaysia; 1999. p. 118–22.

34. Stapley JH. Using the predatory ant, *Oecophylla smaragdina*, to control insect pests of coconuts and cocoa. Information Circular – South Pacific Commission no. 85. 1980.

35. Saarinen EV. Differences in worker caste behaviour of *Oecophylla smaragdina* (Hymenoptera: Formicidae) in response to larvae of *Anthene emolus* (Lepidoptera: Lycaenidae). Biological Journal of the Linnean Society 2006;88:391–5.

36. More PS, Desai BD, Jalangaonkar VN, Mule RS. Record of pests infesting arecanut (*Areca catechu* Linneaus) and their seasonal incidence in Konkan region of Maharashtra. Indian Journal of Arecanut, Spices and Medicinal Plants 2002;4:120–2.

37. Phillips JS. Immature nutfall of coconuts in the British Solomon Islands. Bulletin of Entomological Research 1940;31:295–316.

38. Froggatt JL. *Promecotheca antiqua* Wse. Leaf pest of coconuts. New Guinea Agricultural Gazette 1937;3:21–2.

39. Way MJ, Cammell ME, Bolton B, Kanagaratnam P. Ants (Hymenoptera: Formicidae) as egg predators of coconut pests, especially in relation to biological control of the coconut caterpillar, *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae), in Sri Lanka. Bulletin of Entomological Research 1989;79:219–33.

40. Williams DJ. The Pseudococcidae of the Solomon Islands. Bulletin of the British Museum (Entomology) 1960;8:387–430.

41. Way MJ, Bolton B. Competition between ants for coconut palm nesting sites. Journal of Natural History 1997;31:439–55.

42. Simmonds FJ. Biological control of *Cordia curassavica* (Boraginaceae) in Malaysia. Entomophaga 1980;25:363–4.

43. Fiedler K, Maschwitz U. The symbiosis between the weaver ant, *Oecophylla smaragdina*, and *Anthene emolus*, an obligate myrmecophilous lycaenid butterfly. Journal of Natural History 1989;23:833–46.

44. Hill DS. Agricultural Pests of the Tropics and their Control. 2nd ed. Cambridge University Press, Cambridge; 1983.

45. Dodd FP. Notes on the Queensland green tree ants (*Oecophylla smaragdina*). Victorian Naturalist 1902; 18:136–40.

46. Mahdihassan S. Mixed infection of lac. The Journal of the Bombay Natural History Society 1976;74:551–2.

47. Anon. Scale insects, mealybugs and lac insects. Planter's Bulletin of the Rubber Research Institute of Malaysia 1968;98:146–52.

48. Le Pelley RH. An oriental mealybug (*Pseudococcus lilacinus* Ckll.) and its insect enemies. Transactions of the Royal Entomological Society of London 1943;93:73–93.

49. Valentine P. Australian Tropical Butterflies. Frith and Frith, Queensland, Australia; 1988.

50. Ballmer GR. Observations on resource partitioning among ants (Hymenoptera: Formicidae) and lycaenid larvae (Lepidoptera: Lycaenidae) associated with *Pueraria phaseoloides* in South Thailand. ScienceAsia 2003;29: 197–202.

51. Green EE. Remarks on Coceidae collected by Mr Edward Jacobson, of Samarang, Java, with descriptions of two new species. Tijdschrift voor Entomologie 1913;55:311–8.

52. Macnae W. A general account of fauna and flora of mangrove swamps and forests in Indo-West-Pacific Region. Advances in Marine Biology 1968;6:73–270.

53. Tan R. Mangrove and Wetland Wildlife at Sungei Buloh Wetlands Reserve: Weaver Ants. 2001. Available from: URL: http://www.naturia.per.sg/buloh/inverts/weaver_ants.htm (accessed 14 October 2006).

54. Jesudasan RW, Claver MA, Priyakumari CJ, Ragupathy E. Some ethological observations in whitefly and ant interaction. Journal of Applied Zoological Researches 2004;15:17–21.

55. Khoo SG. *Hypsipyla* shoot borers of Meliaceae in Malaysia. In: Floyd RB, Hauxwell C, editors. Proceedings of an International Workshop on *Hypsipyla* Shoot Borers in Meliaceae. ACIAR, Canberra; 2001. p. 24–30.

56. Quick WNB. Early stages of the life cycle of *Narathura araxes eupolis* (Miskin) (Lepidoptera: Lycaenidae). The Victorian Entomologist 1974;4:24.

57. Jinda L. The weaver ants, *Oecophylla longinoda, Oecophylla smaragdina*, Malaysia. Nature Malaysiana 1982;7:16–17.

58. Benzie JAH. Selective positioning of arboreal tents by weaver ants *Oecophylla smaragdina* (F.): A possible co-evolutionary development with maha-dan trees, *Syzygium cumini* (L.) Skeeis. Australian Entomological Magazine 1985;12:17–19.

59. Chantaranothai P, Parnell JAN. The breeding biology of some Thai *Syzygium* species. Tropical Ecology 1994;35:199–208.

60. Balakrishnan MM, Vinodkumar PK, Prakasan CB. A note of green scale-ant association on coffee. Indian Coffee, Bulletin of the Indian Coffee Board 1992;56:5–6.

61. Miller NCE. *Coccus* (*Lecanium*) *viridis* Green: the 'Green scale' of coffee. In: Federated Malay States Government Press, Malaya (Malaysia); 1931. p. 17–29.

62. Van Mele P, Cuc NTT, Van Huis A. Direct and indirect influences of the weaver ant *Oecophylla smaragdina* on citrus farmers' pest perceptions and management practices in the Mekong Delta, Vietnam. International Journal of Pest Management 2002;48:225–32.

63. Greenslade PJM. Phenology of three ant species in the Solomon Islands. Journal of the Australian Entomological Society 1971;10:241–52.

64. Leu AF. Organic lychee and rambutan production. In: Chomchalow N, Sukhvibul N, editors. Proceedings of the Second International Symposium on Lychee, Longan, Rambutan and Other Sapindaceae Plants. ISHS, Thailand; 2005. p. 241–54.

65. Tsuji K, Hasyim A, Harlion, K. Nakamura. Asian weaver ants, *Oecophylla smaragdina*, and their repelling of pollinators. Ecological Research 2004;19:669–73.

66. Das GM. Observations on the association of ants with coccids of tea. Bulletin of Entomological Research 1959;50:437–48.

67. Djieto-Lordon C, Dejean A. Tropical arboreal ant mosaics: innate attraction and imprinting determine nest site selection in dominant ants. Behavioral Ecology and Sociobiology 1999;45:219–25.

68. Hölldobler B. Territories of the African weaver ant. Zeitschrift fur Tierpsychologie 1979;51:201–13.

69. Strickland AH. The entomology of swollen shoot of cacao. II. The bionomics and ecology of the species involved. Bulletin of Entomological Research 1951;42:65–103.

70. Pierce NE, Braby MF, Heath A, Lohman DJ, Mathew J, Rand DB, *et al.* The ecology and evolution of ant associations in the Lycaenidae (Lepidoptera). Annual Review of Entomology 2002;47:733–71.

71. Bishop S. Pest Risk Analysis for *Cerataphis lataniae* Boisduval. Central Science Laboratory, York, UK; 2005. Available from: URL: http://www.defra.gov.uk/planth/pra/Ceratap.pdf (accessed 1 December 2007).

72. Butani DK. Insect pests of fruit crops and their control: jackfruit. Pesticides 1979;13:36–40.

73. Way MJ. Studies on the association of the ant *Oecophylla longinoda* (Latr.) with the scale insect *Saissetia zanzibarensis* Williams. Bulletin of Entomological Research 1954;45:113–34.

74. Van Mele P. Mission de prospection sur les fourmis rouges dans les vergers de mangues biologiques et développement des activités pour découvrir en pratiquant. FAO, Rome; 2007.

75. Van Mele P. A historical review of research on the weaver ant *Oecophylla* in biological control. Agricultural and Forest Entomology 2008;10:13–22.

76. Van Mele P. Evaluating Farmers' Knowledge, Perceptions and Practices: A Case Study of Pest Management by Fruit Farmers in the Mekong Delta, Vietnam. Wagenigen University, The Netherlands; 2000.

77. Van Mele P, Chien HV. Farmers, biodiversity and plant protection: developing a learning environment for sustainable tree cropping systems. Journal of Agricultural Sustainability 2004;2:67–76.

78. Peng RK, Christian K. The weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae), an effective biological control agent of the red-banded thrips, *Selenothrips rubrocinctus* (Thysanoptera: Thripidae) in mango crops in the Northern Territory of Australia. International Journal of Pest Management 2004;50:107–14.