Lacewings and Scale Insects: A Review of Predator/Prey Associations Between the Neuropterida and Coccoidea (Insecta: Neuroptera, Raphidioptera, Hemiptera)

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ABSTRACT Information on 263 Neuropterida/Coccoidea associations with additional detailed data on the most commonly encountered taxa is presented. Included for each entry, where applicable, is the predator, Coccoidea prey, validation source, prey plant host, and biogeographic origin.

KEY WORDS scale insects, biological control, lacewings, snakeflies, biogeographic origin

RECENT CONCERNS ABOUT THE potential negative impacts of invasive scale insect species on agricultural crops (Miller et al. 2002, 2005, Miller and Miller 2003) has heightened interest in the predators of these species and predators of the Coccoidea in general. Insects belonging to several families of the superorder Neuropterida are well-known predators of small arthropods—including scale insects—that inhabit plant surfaces. Chief among these groups are the large and cosmopolitan families Chrysopidae (green lacewings), Hemerobiidae (brown lacewings), and Coniopterygidae (dustywings), but notable predators are also found in the smaller families of Raphidioptera, Inocelliidae (snakeflies), and Raphidiidae (snakeflies). Although typically considered generalist predators as a group, different species in these families actually exhibit a range of acceptable prey breadths. Many species are general predators, but it has long been known that other species in these families exhibit moderate to strong "host plant" associations, and that these associations are best explained as a result of specialized predators feeding on plant-host–restricted herbivore prey (Monserrat and Marín 2001). The ubiquity, plant-associated biologies, and sessile lifestyles of scale insects combine to render them a major class of prey species for many predaceous neuropterids. The high levels of host plant specificity exhibited by scale insects suggest that specialized scale feeding might help explain many cases of neuropterid "host plant" association. Conversely, the search for specialized scale predators for use in biological control might benefit from additional investigation of prey-specialized neuropterid insects. Although neuropterids are generally considered beneficial insects in agricultural situations, they can also be pests when lacewing populations feed on scale insects of commercial importance, e.g., lac and cochineal insects, used for shellac and carmine dye production, respectively. In such cases, lacewing predation can be of economic concern (Mishra et al. 1996, Portillo Martinez and Vigueras 1998).

ScaleNet (Ben-Dov et al. 2004) and Bibliography of the Neuropterida (Oswald 2004) are two web sites that concentrate on the biology of scale insects and neuroterids, respectively. Both these sites have large searchable databases. Several general references contain synoptic information about the prey of neuropterid species (Killington 1936; Balduf 1939; Herting and Simmonds 1972a, b; Drea 1990; Singh and Narasimham 1992). However, with the exception of Drea's study of the Neuroptera associated with armored scales (Diaspididae), no works have focused specifically on a broad assessment of neuropterid/coccoid predator/prey associations, and no comprehensive framework is currently available within which the potential impact of such associations on the adventive scale fauna of the United States can be evaluated. The objectives of this study are to (1) provide an extensive, referenced, tabulation of neuropterid/coccoid predator/prey associations worldwide; (2) couple these associations with validated information on scale hosts and zoogeographic origins; and (3) review these data for patterns of biological and/or biological control interest.

Materials and Methods

Primary and secondary literature sources, ScaleNet (Ben-Dov et al. 2004), and Bibliography of the Neuropterida (Oswald 2004) were searched to identify references that cited neuropterid/coccoid predator/prey associations. Extensive attempts were made to obtain relevant literature and to verify from original references all associations cited in secondary sources. However, with any work of this scope, there are un-

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Table 1. Neuropterida/Coccoidea predator/prey associations

Neuropterida family	Neuropterida species (predator)	Coccoidea family	Scale species (prey)	Predator/prey association reference	Principal scale hosts	Scale origin and reference
Chrysopidae	*Ankylopteryx* sp.	Coccidae	*Pulvinaria* sp.	Singh and Narasimham 1992:13	—	—
Chrysopidae	*Apertochrysa* sp.	Pseudococcidae	*Maconellicoccus hirsutus* (Green)	Krishnamoorthy and Mani 1989:155	Polyphagous	OR Williams 1996
Chrysopidae	*Borniochrysa squamosus* (Tjeder) (as *Suarius squamosus*)	Pseudococcidae	*Rastrococcus invadens* Williams	Agounké et al. 1988:699	Polyphagous, especially tropical fruits	OR Williams 1986
Chrysopidae	*Brinckochrysa scelestes* (Banks)[a] *(as Chrysopa scelestes)*	Margarodidae	*Drosicha stebbingi* Green (as *Monophlebus stebblingi* var. *octocaudata*)	Rahman 1940:73; Rahman and Abdul Latif 1944:205	Fruit trees	OR Morrison 1928
Chrysopidae	*Brinckochrysa scelestes* (Banks)[a] *(some as Chrysopa scelestes)*	Pseudococcidae	*Maconellicoccus hirsutus* (Green)	Rao et al. 1984a:83, 1984b:12; Mani 1989:162	Polyphagous	OR Williams 1996
Chrysopidae	*Ceraeochrysa cincta* (Schneider) (as *Chrysoperla bicarnea*)	Diaspididae	*Fiorinia theae* Green	Nguyen and Bennett 1994:126	Polyphagous	OR Munir and Sailer 1985
Chrysopidae	*Ceraeochrysa claveri* (Navás)	Diaspididae	*Fiorinia theae* Green	Nguyen and Bennett 1994:126	Polyphagous	OR Munir and Sailer 1985
Chrysopidae	*Ceraeochrysa claveri* (Navás) (as *Chrysopa claveri* or *Chrysopa silvana*)	Pseudococcidae	*Saccharicoccus sacchari* (Cockerell)	Guagliumi 1962[b]	Sugar cane	NT(?) Miller et al. 2002
Chrysopidae	*Ceraeochrysa cubana* (Hagen) (as *Chrysopa cubana* or *Chrysopa lateralis*, misidentification, see Muma 1957:5 footnote)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus) (some as *Chrysomphalus ficus*)	Mathis 1947:34; Muma 1957:7; Muma 1959b:579; Muma et al. 1961:29	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Ceraeochrysa cubana* (Hagen) (as *Chrysopa cubana* or *Chrysopa lateralis*, misidentification, see Muma 1957:5 footnote)	Diaspididae	*Lepidosaphes beckii* (Newman)	Muma 1957:7; Muma et al. 1961:29	Polyphagous, citrus	OR Gill 1997
Chrysopidae	*Ceraeochrysa cubana* (Hagen) (as *Chrysopa cubana*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Muma et al. 1961:31	Polyphagous	OR Bartlett 1978
Chrysopidae	*Ceraeochrysa sanchezi* (Navás) (as *Chrysopa sanchezi*)	Diaspidiae	*Chrysomphalus aonidum* (Linnaeus)	Muma et al. 1961:29	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Ceraeochrysa sanchezi* (Navás) (as *Chrysopa sanchezi*)	Pseudococcidae	*Planococcus citri* (Risso)	Muma et al. 1961:31	Polyphagous	OR Bartlett 1978
Chrysopidae	*Ceraeochrysa valida* (Banks) (as *Chrysopa bimaculata*)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus)	Muma 1959a:23; Muma 1959b: 579; Muma et al. 1961:31	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Ceraeochrysa valida* (Banks) (as *Chrysopa bimaculata*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Muma 1959a:23; Muma et al. 1961:31	Polyphagous	OR Bartlett 1978
Chrysopidae	*Ceratochrysa antica* (Walker) (as *Nothochrysa antica*)	Pseudococcidae	*Pseudococcus* spp.	Kirkpatrick 1926:191	—	—
Chrysopidae	"*Chrysopa albifrons*" (?) (lapsus/ misidentification, no such species name known)	Coccidae	*Saissetia coffeae* (Walker)	Aguilar F. et al. 1980a:101	Polyphagous	AF Gill 1988
Chrysopidae	*Chrysopa formosa* Brauer	Diaspididae	*Aulacaspis citri* Chen	Lin et al. 1997:445	Citrus	PA, OR Chen 1954
Chrysopidae	*Chrysopa nigricornis* Burmeister	Coccidae	*Mesolecanium nigrofasciatum* (Pergande) (as *Eulecanium nigrofasciatum*)	Simanton 1916:63	Deciduous fruit trees	NE Miller and Miller 2003
Chrysopidae	*Chrysopa nigricornis* Burmeister (as *Chrysopa majuscula*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Cole 1933:862	Polyphagous	PA Cox 1989

Chrysopidae	*Chrysopa nigricornis* Burmeister	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Haeussler and Clancy 1944:507	Fruit trees and ornamental plants	PA Bartlett 1978
Chrysopidae	*Chrysopa oculata* Say	Pseudococcidae	*Phenacoccus gossypii* Townsend and Cockerell	Heming 1936:633	Polyphagous	NE Miller et al. 2002
Chrysopidae	*Chrysopa oculata* Say	Pseudococcidae	*Pseudococcus maritimus* (Ehrhorn)	Grimes and Cone 1985:557	Polyphagous	NE Miller et al. 2002
Chrysopidae	*Chrysopa pallens* (Rambur) (as *Chrysopa septempunctata*)	Diaspididae	*Diaspidiotus perniciosus* (Comstock) (as *Quadraspidiotus perniciosus*)	Kosztarab and Kozár 1988:377	Polyphagous	PA Rosen DeBach 1978
Chrysopidae	*Chrysopa pallens* (Rambur) (as *Chrysopa septempunctata*)	Margarodidae	*Marchalina hellenica* (Gennadius)	Argyriou et al. 1976:22	Pines	PA Morrison 1928
Chrysopidae	*Chrysopa pallens* (Rambur) (as *Chrysopa septempunctata*)	Pseudococcidae	*Phenacoccus azaleae* Kuwana	Xie et al. 1999:382	Azalea	PA Miller et al. 2002
Chrysopidae	*Chrysopa pallens* (Rambur) (as *Chrysopa centralis* or *Chrysopa septempunctata*)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Meier 1948:84; Yasnosh 1962[b]	Fruit trees and ornamental plants	PA Bartlett 1978
Chrysopidae	*Chrysopa perla* (Linnaeus)	Coccidae	*Parthenolecanium corni* (Bouché)	Kosztarab and Kozár 1988:221	Polyphagous	PA Miller and Miller 2003
Chrysopidae	"*Chrysopa perla*" (Linnaeus) (probably misidentified, not known from Guatemala or elsewhere in the New World)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Alvarado 1935:229	Polyphagous	OR Bartlett 1978
Chrysopidae	"*Chrysopa perla*" (Linnaeus) (probably misidentified, not known from Guatemala or elsewhere in the New World)	Pseudococcidae	*Pseudococcus* spp.	Alvarado 1935:227	—	—
Chrysopidae	*Chrysopa quadripunctata* Burmeister	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Haeussler and Clancy 1944:507	Fruit frees and ornamental plants	PA Bartlett 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Coccidae	*Coccus viridis* (Green)	Parker et al. 1953:34	Polyphagous	AF Gill et al. 1977
Chrysopidae	"*Chrysopa*" sp.[c]	Coccidae	*Neopulvinaria innumerabilis* (Rathvon) (as *Pulvinaria innumerabilis*)	Kosztarab 1996:383	Polyphagous	NE Miller and Miller 2003
Chrysopidae	"*Chrysopa*" sp.[c]	Coccidae	*Saissetia oleae* (Olivier)	Beingolea 1955:19; Argyriou et al. 1976:24	Polyphagous	AF Bartlett 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Coccidae	*Sphaerolecanium prunastri* (Boyer de Fonscolombe)	Kosztarab and Kozár 1988:256	Fruit trees	PA Hodgson 1994
Chrysopidae	"*Chrysopa*" sp.[c]	Diaspididae	*Aspidiotus destructor* Signoret	Simmonds 1921:15; Brugiroux 1928:400	Polyphagous, palms	AU? Balachowsky 1948
Chrysopidae	"*Chrysopa*" sp.[c]	Diaspididae	*Chrysomphalus aonidum* (Linnaeus)	Muma 1959a:26	Polyphagous	OR Rosen and DeBach, 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Diaspididae	*Diaspidiotus perniciosus* (Comstock) (as *Quadraspidiotus perniciosus*)	Tsalev 1974[b]	Polyphagous	PA Rosen and DeBach 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Diaspididae	*Lepidosaphes beckii* (Newman)	Carnegie 1959:10	Polyphagous, citrus	OR Gill 1997
Chrysopidae	"*Chrysopa*" sp.[c]	Diaspididae	*Parlatoria blanchardi* (Targioni Tozzetti)	Kehat 1967:120	Palms, date palm	PA Rosen and DeBach 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Diaspididae	*Tecaspis* sp.	Ahmad and Ghani 1972[b]	—	—
Chrysopidae	"*Chrysopa*" sp.[c]	Diaspididae	*Unaspis yanonenis* (Kuwana)	Ishii 1931[b]	Citrus	PA Rosen and DeBach 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Kerriidae	*Kerria lacca* (Kerr) (by implication as *Tachardia lacca*)	Fowler 1921:11	Polyphagous	OR Kapur 1958

Table 1. Continued

Neuropterida family	Neuropterida species (predator)	Coccoidea family	Scale species (prey)	Predator/prey association reference	Principal scale hosts	Scale origin and reference
Chrysopidae	"*Chrysopa*" sp.[c]	Margarodidae	*Icerya purchasi* Maskell	Wolcott and Martorell 1944: 451; Singh and Narasimham 1992:18	Fruit trees	AU Bartlett 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Margarodidae	*Matsuoccus matsumurae* (Kuwana) (as *Matsucoccus resinosae*)	Bean and Goldwin 1955:175	Pines	PA McClure 1983
Chrysopidae	"*Chrysopa*" sp.[c]	Pseudococcidae	*Ferrisia virgata* (Cockerell)	Rawat and Modi 1968:52, 1970: 516	Polyphagous	NT(?) Williams and Granara de Willink 1992
Chrysopidae	"*Chrysopa*" sp.[c]	Pseudococcidae	*Maconellicoccus hirsutus* (Green)	Mani et al. 1987:624	Polyphagous	OR Williams 1996
Chrysopidae	"*Chrysopa*" sp.[c]	Pseudococcidae	*Paracoccus solani* Ezzat and McConnell (as *Gossypina glauca*)	Aguilar F. and Lamas C. 1980: 91	Polyphagous	NE or NT Williams and Granara de Willink 1992
Chrysopidae	"*Chrysopa*" sp.[c]	Pseudococcidae	*Phenacoccus gossypii* Townsend and Cockerell	Aguilar F. and Lamas C. 1980: 91	Polyphagous	NE Miller et al. 2002
Chrysopidae	"*Chrysopa*" sp.[c]	Pseudococcidae	*Planococcus citri* (Risso) (some as *Pseudococcus citri*)	Pariser 1917:20; Argyriou et al. 1976:22	Polyphagous	OR Bartlett 1978
Chrysopidae	"*Chrysopa*" sp.[c]	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	Charles 1989:231	Polyphagous	AU Miller et al. 2002
Chrysopidae	"*Chrysopa*" sp.[c]	Pseudococcidae	*Pseudococcus neomaritimus* Beardsley	Aguilar F. and Lamas C. 1980: 91	Tropical plants	Pacific Isl. Gimpel and Miller 1996
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea*)	Coccidae	*Ceroplastes sinensis* Del Guercio	Argyriou et al. 1976:23	Polyphagous, including citrus and ornamentals	NT Qin et al. 1994
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa vulgaris*)	Coccidae	*Parthenolecanium persicae* (Fabricius) (as *Lecanium persicae*)	Feytaud 1916:45	Polyphagous, including peach	PA Miller et al., in press
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Coccidae	*Protopulvinaria pyriformis* (Cockerell)	Swirski et al. 1997:233	Polyphagous	NT(?) Miller et al., in press
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa vulgaris*)	Coccidae	*Pulvinaria horii* Kuwana	Gaprindashvili, 1956:135	Trees	PA Miller and Miller 2003
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Coccidae	*Pulvinaria tenuivalvata* (Newstead)	El-Serwy 2001:31	Poaceae	AF
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (some as *Chrysopa carnea*)	Coccidae	*Pulvinaria vitis* (Linnaeus)	Kosztarab and Kozár 1988:244; Kosztarab 1996:386; Pellizzari 1997:325	Polyphagous	PA Hodgson 1994
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa vulgaris*)	Coccidae	*Pulvinaria floccifera* (Westwood)	Gaprindashvili 1956:127	Polyphagous, including citrus and ornamentals	PA Steinweden1946
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa vulgaris*)	Coccidae	*Saissetia oleae* (Olivier)	Gaprindashvili 1956:135	Polyphagous	AF Barlett 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Diaspididae	*Aonidiella orientalis* (Newstead)	Wysoki et al. 1995:267	Palms	OR McKEnzie 1938
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Diaspididae	*Aspidiotus nerii* Bouché	Argyriou and Kourmadas 1980: 637	Polyphagous	AU? Ferris 1941 or AF? Balachowski 1948
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa shansiensis*)	Diaspididae	*Aulacaspis citri* Chen	Lin et al. 1997:446	Citrus	PA or OR Chen 1954

Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (*Chrysopa vulgaris*)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus) (as *Chrysomphalus ficus*)	Priesner 1931:18	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea*)	Diaspididae	*Diaspidiotus perniciosus* (Comstock) (as *Quadraspidiotus perniciosus*)	Kosztarab and Kozár 1988:377	Polyphagous	PA Rosen and DeBach 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa vulgaris*)	Diaspididae	*Lepidosaphes tapleyi* Williams	Swailem 1973:71	Polyphagous	AF(?) Williams and Watson 1990
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea* or *Chrysopa vulgaris*)	Diaspididae	*Parlatoria blanchardi* (Targioni Tozzetti)	Smirnoff 1953:146; Smirnoff 1956:12	Palms, date palm	PA Rosen and DeBach 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea*)	Diaspididae	*Unaspis yanonensis* (Kuwana)	Noguchi 1941[b]	Citrus	PA Rosen and DeBach 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea*)	Margarodidae	*Matsucoccus josephi* Bodenheimer and Harpaz	Bodenheimer and Neumark 1955:71	Pines	PA Mendel et al. 1990
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Margarodidae	*Matsucoccus* sp.	Principi and Canard 1984:83	Pines	PA, NE Morrison 1928
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Ortheziidae	*Orthezia tillandsiae* Morrison	Voigt 2000:151	*Tillandsia* spp.	NE
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Pseudococcidae	*Ferrista virgata* (Cockerell)	Krishnamoorthy and Mani 1989:155	Polyphagous	NT(?) Williams and Grana de Willink 1992
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (some as *Chrysopa carnea* or *Chrysopa vulgaris*)	Pseudococcidae	*Maconellicoccus hirsutus* (Green) (some as *Phenacoccus hirsutus*)	Hall 1921:24; Mani 1989:162	Polyphagous	OR Williams 1996
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (some as *Chrysopa vulgaris* var. *viridella*)	Pseudococcidae	*Planococcus citri* (Risso) (some as *Pseudococcus citri*)	Ruis Castro 1942:184; Krishnamoorthy and Mani 1989:155	Polyphagous	OR Bartlett 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Pseudococcidae	*Planococcus vovae* (Nasonov)	Lotfalizadeh and Ahmadi 2000: 149	Cypress	PA Miller et al. 2002
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea*)	Pseudococcidae	*Pseudococcus calceolariae* (Maskell) (as *Pseudococcus gahani*)	Stepanov 1933[b]	Polyphagous, including citrus	AU Bartlett 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea* or *Chrysopa vulgaris*)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Meier 1948:84	Fruit trees and ornamental plants	PA Bartlett 1978
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Pseudococcidae	*Pseudococcus cryptus* Hempel	Blumberg et al. 1999:235	Polyphagous	NT(?) Miller et al. 2002
Chrysopidae	*Chrysoperla carnea* (Stephens)[d]	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	Swirski et al. 1980:422	Polyphagous	AU Miller et al. 2002
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea* or *Chrysopa vulgaris*)	Pseudococcidae	*Pseudococcus maritimus* (Ehrhorn)	Gaprindashvili 1956:134; Grimes and Cone 1985:557	Polyphagous	NE Miller et al. 2002
Chrysopidae	*Chrysoperla carnea* (Stephens)[d] (as *Chrysopa carnea*)	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Chrysopidae	*Chrysoperla externa* (Hagen)	Diaspididae	*Parlatoria cinerea* Hadden	Gravena et al. 1993:151	Polyphagous, tropical fruits	uncertain Williams and Watson 1988
Chrysopidae	*Chrysoperla externa* (Hagen)	Diaspididae	*Selenaspidus articulatus* (Morgan)	Xavier et al. 1997:135	Polyphagous	AF McKenzie 1953
Chrysopidae	*Chrysoperla furcifera* (Okamoto) (as *Chrysopa kulingensis*)	Margarodidae	*Matsucoccus* sp.	Wang and Hu 1987:26	Pines	PA, NE Morrison 1928
Chrysopidae	*Chrysoperla harrisii* (Fitch)	Diaspidae	*Fiorinia theae* Green	Nguyen and Bennett 1994:126	Polyphagous	OR Munir and Sailer 1985
Chrysopidae	*Chrysoperla nipponensis* (Okamoto) (as *Chrysopa sinica*)	Diaspididae	*Aulacaspis citri* Chen	Lin et al. 1997:445	Citrus	PA or OR Chen 1954

Table 1. Continued

Neuropterida family	Neuropterida species (predator)	Coccoidea family	Scale species (prey)	Predator/prey association reference	Principal scale hosts	Scale origin and reference
Chrysopidae	*Chrysoperla orestes* (Banks) (as *Chrysopa orestes*)	Pseudococcidae	*Ferrisia virgata* (Cockerell)	Patniak and Bhagat 1984:4	Polyphagous	NT(?) Williams and Granara de Willink 1992
Chrysopidae	*Chrysoperla orestes* (Banks) (as *Chrysopa orestes*)	Pseudococcidae	*Rastrococcus iceryoides* (Green) (inferred host)	Patnaik and Bhagat 1984:1	Polyphagous	OR Ben-Dov 1994
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Coccidae	*Parasaissetia nigra* (Nietner) (as *Saissetia nigra*)	Smith 1944:275	Polyphagous	AF or OR Gill 1988
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Coccidae	*Parthenolecanium pruinosum* (Coquillet) (as *Eulecanium pruinosum*)	Essig 1915:151	*Prunus* and *Robinia*	NE Miller and Miller 2003
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa plorabunda*)	Coccidae	*Pulvinaria vitis* (Linnaeus)	Phillips 1963:401	Polyphagous	PA Hodgson 1994
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Diaspididae	*Aonidiella aurantii* (Maskell) (as *Chrysomphalus aurantii*)	Essig 1913:134; Essig 1915:154	Citrus	OR McKenzie 1938
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa plorabunda*)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus)	Muma 1959b:579	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Diaspididae	*Hemiberlesia lataniae* (Signoret)	Ebeling 1959:297	Polyphagous	uncertain Gill 1997
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Diaspididae	*Lepidosaphes beckii* (Newman)	Essig 1913:137; Essig 1915:188	Polyphagous, citrus	OR Egling 1959
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Eriococcidae	*Eriococcus spurius* (Modeer) (as *Gossyparia spuria*)	Herbert 1924:12	Elm	PA Kosztarab 1996
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Essig 1913:103; Cole 1933:862; Doutt 1951:38	Polyphagous	OR Bartlett 1978
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa plorabunda* or *Chrysopa californica*)	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti) (some as *Pseudococcus adonidum*)	DeBach 1949:17; DeBach et al. 1949:777; Ebling 1959:182	Polyphagous	AU Miller et al. 2002
Chrysopidae	*Chrysoperla plorabunda* (Fitch) (as *Chrysopa californica*)	Pseudococcidae	*Pseudococcus maritimus* (Ehrhorn) (or *maritimus* complex)	Doutt 1948:116; Doutt and Hagen 1949:560; Doutt and Hagen 1950:95	Polyphagous	NE Miller et al. 2002
Chrysopidae	*Chrysoperla pudica* (Navás)	Margarodidae	*Icerya pattersoni* (Newstead)	Kinuthia and Mwangi 1990:587	Coffee	AU Wanjala et al. 1986
Chrysopidae	*Chrysoperla rufilabris* (Burmeister) (as *Chrysopa rufilabris*)	Coccidae	*Coccus hesperidum* Linnaeus	Muma et al. 1961:30	Polyphagous	OR
Chrysopidae	*Chrysoperla rufilabris* (Burmeister) (as *Chrysopa rufilabris* or *C. interrupta*)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus) (some as *Chrysomphalus ficus*)	Muma 1959b:579; Muma et al. 1961:29	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Chrysoperla rufilabris* (Burmeister)	Diaspididae	*Fiorinia theae* Green	Nguyen and Bennett 1994:126	Polyphagous	OR Munir and Sailer 1985
Chrysopidae	*Chrysoperla rufilabris* (Burmeister) (as *Chrysopa rufilabris*)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Hough 1925:25; Haeussler and Clancy 1944:507	Fruit trees and ornamental plants	PA Bartlett 1978
Chrysopidae	*Chrysoperla* sp. (as *Chrysopa* sp. near *carnea* grp.)	Margarodidae	*Matsucoccus matsumurae* (Kuwana)	Kosztarab 1996:48	Pines	PA McClure 1983
Chrysopidae	*Chrysopidia ciliata* (Wesmael) (as *Chrysopa ciliata*)	Eriococcidae	*Cryptococus fagisuga* Lindinger	Kosztarab and Kozár 1988:270	*Fagus* spp.	PA Ehrlich 1932
Chrysopidae	*Chrysopidia ciliata* (Wesmael) (as *Chrysopa ciliata*)	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—

Chrysopidae	*Chrysopodes collaris* (Schneider) (as *Chrysopa collaris*)	Margarodidae	*Icerya purchasi* Maskell	Leonard 1932:1106	Fruit trees	AU Bartlett 1978
Chrysopidae	*Cunctochrysa albolineata* (Killington) (as *Chrysopa tenella* Schneider)	Coccidae	*Pulvinaria vitis* (Linnaeus) (as *Pulvinaria betulae*)	Withycombe 1922:558	Polyphagous	PA Hodgson 1994
Chrysopidae	*Cunctochrysa albolineata* (Killington) (as *Chrysopa albolineata*)	Pseudococcidae	*Planococcus kraunhiae* (Kuwana)	Kuwayama 1962:365	Polyphagous	PA Cox 1989
Chrysopidae	*Cunctochrysa albolineata* (Killington) (as *Chrysopa albolineata*)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Yasnosh 1962[b]	Fruit trees and ornamental plants	PA Barlettt 1978
Chrysopidae	*Dichochrysa aegyptiaca* (Navás) (as *Chrysopa vulgaris aeqyptiaca*)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus) (as *Chrysomphalus ficus*)	Priesner and Hosny 1940:64	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Dichochrysa aegyptiaca* (Navás) (as *Chrysopa vulgaris aeqyptiaca*)	Margarodidae	*Icerya aegyptiaca* Douglas	Priesner and Hosny 1940:64	Polyphagous	OR Bartlett 1978
Chrysopidae	*Dichochrysa aegyptiaca* (Navás) (as *Chrysopa vulgaris aeqyptiaca*)	Pseudococcidae	*Maconellicoccus hirsutus* (Green) (as *Phenacoccus hirsutus*)	Priesner and Hosny 1940:64	Polyphagous	OR Williams 1996
Chrysopidae	*Dichochrysa aegyptiaca* (Navás) (as *Chrysopa vulgaris aeqyptiaca*)	Pseudococcidae	*Nipaecoccus viridis* (Newstead) (as *Pseudococcus filamentosus*, misidentification, see Herting and Simmonds 1972b:115, where cited as *Nipaecoccus vastator* a jr.syn. of *viridis*)	Priesner and Hosny 1940:64	Polyphagous	OR(?) Miller et al. 2002
Chrysopidae	*Dichochrysa cognatella* (Okamoto) (as *Chrysopa cognatella*)	Coccidae	*Pulvinaria aurantii* Cockerell	Tachikawa 1962:38	Polyphagous	OR(?)
Chrysopidae	*Dichochrysa flavifrons* (Brauer) (as *Chrysopa flavifrons*)	Diaspididae	*Pinnaspis aspidistrae* (Signoret)	Aguilar F. et al. 1980b:99	Polyphagous, including ferns	OR Ferris and Rao 1947
Chrysopidae	*Dichochrysa flavifrons* (Brauer) (as *Chrysopa flavifroms*)	Margarodidae	*Marchalina hellenica* (Gennadius)	Argyriou et al. 1976:22	Pines	PA Morrison 1928
Chrysopidae	*Dichochrysa prasina* (Burmeister) (as *Chrysopa aspersa*)	Coccidae	*Parthenolecanium refulum* (Cockerell) (as *Eulecanium pulchrum*)	Schmutterer 1952:84	Polyphagous, including deciduous forest trees	PA Miller and Miller 2003
Chrysopidae	*Dichochrysa prasina* (Burmeister) (as *Chrysopa caucasica*)	Coccidae	*Pulvinaria floccifera* (Westwood)	Gaprindashvili 1956:127	Polyphagous, including citrus and ornamentals	PA Steinweden 1946
Chrysopidae	*Dichochrysa prasina* (Burmeister) (as *Chrysopa caucasica*)	Coccidae	*Pulvinaria horii* Kuwana	Gaprindashvili 1956:135	Trees	PA Miller and Miller 2003
Chrysopidae	*Dichochrysa prasina* (Burmeister) (as *Chrysopa caucasica*)	Coccidae	*Saissetia oleae* (Olivier)	Gaprindashvili 1956:135	Polyphagous	AF Bartlett 1978
Chrysopidae	*Dichochrysa prasina* (Burmeister) (as *Chrysopa prasina*)	Diaspididae	*Diaspidiotus perniciosus* (Comstock) (as *Quadraspidiotus perniciosus*)	Kosztarab and Kozár 1988:377	Polyphagous	PA Rosen and DeBach 1978
Chrysopidae	*Dichochrysa prasina* (Burmeister) (as *Mallada prasinus*)	Pseudococcidae	*Plannoccus ficus* (Signoret)	Dalla Montá et al. 2002 (2001): 345	Polyphagous, including grapes	PA Cox 1989
Chrysopidae	*Dichochrysa prasina* (Burmeister) (as *Chrysopa caucasica*)	Pseudococcidae	*Pseudococcus maritimus* (Ehrhorn)	Gaprindashvili 1956:134	Polyphagous	NE Miller et al. 2002
Chrysopidae	*Dichochrysa venosa* (Rambur) (as *Chrysopa venosa*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Ruiz Castro 1942:184	Polyphagous	OR Bartelett 1978
Chrysopidae	*Dichochrysa ventralis* (Curtis) (as *Chrysopa ventralis*)	Eriococcidae	*Cryptococcus fagisuga* Lindinger	Kosztarab and Kozár 1988:270	*Fagus* spp.	PA Ehrlich 1932

Table 1. Continued

Neuropterida family	Neuropterida species (predator)	Coccoidea family	Scale species (prey)	Predator/prey association reference	Principal scale hosts	Scale origin and reference
Chrysopidae	*Dichochrysa ventralis* (Curtis) (as *Chrysopa ventralis*)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Yasnosh 1962[b]	Fruit trees and ornamental plants	PA Bartlett 1978
Chrysopidae	*Dichochrysa* sp. (as *Mallada* sp., *flavifrons* group)	Pseudococcidae	*Phenacoccus madeirensis* Green	Sinacori and Tsolakis 1994:40	Polyphagous	NT Williams 1987
Chrysopidae	*Glenochrysa irregularis* (Banks) (as *Chrysopa irregularis*)	Pseudococcidae	*Dysmicoccus brevipes* (Cockerell) (as *Pseudococcus brevipes*)	Lever 1940:99	Polyphagous	NT Carter 1935
Chrysopidae	*Leucochrysa floridana* Banks (as *Nodita floridana*)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus)	Muma 1959a:28; Muma 1959b: 579	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Mallada albofacialis* Winterton	Margarodidae	*Icerya aegyptiaca* Douglas	Winterton 1995:24	Polyphagous	OR Bartlett 1978
Chrysopidae	*Mallada anpingensis* (Esben-Petersen) (as *Chrysopa vulgaris* var. *anpingensis*)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus)	Matsuda 1928:105	Polyphagous	OR Rosen and DeBach 1978
Chrysopidae	*Mallada anpingensis* (Esben-Petersen) (as *Chrysopa vulgaris* var. *anpingensis*)	Kerriidae	*Tachardina theae* Green and Mann	Matsuda 1928:105	Polyphagous	OR Kapur 1958
Chrysopidae	*Mallada anpingensis* (Esben-Petersen) (as *Chrysopa vulgaris* var. *anpingensis*)	Margarodidae	*Icerya purchasi* Maskell	Matsuda 1928:105	Fruit trees	AU Bartlett 1978
Chrysopidae	*Mallada anpingensis* (Esben-Petersen) (as *Chrysopa vulgaris* var. *anpingensis*)	Pseudococcidae	*Nippaecoccus filamentosus* (Cockerell) (as *Pseudococcus filamentosus*)	Matsuda 1928:105	Polyphagous	NT
Chrysopidae	*Mallada anpingensis* (Ebsen-Petersen) (as *Chrysopa vulgaris* var. *anpingensis*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Matsuda 1928:105	Polyphagous	OR Bartlett 1978
Chrysopidae	*Mallada basalis* (Walker) (as *Anisochrysa basalis*)	Pseudococcidae	*Planococcus citri* (Risso)	Krishnamoorthy and Mani 1989:155	Polyphagous	OR Bartlett 1978
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Mallada boninensis*)	Coccidae	*Ceroplastes japonicus* Green	Miyanoshita and Kawai 1992: 197	Polyphagous	PA Qin et al. 1998
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Chrysopa boninensis*)	Diaspididae	*Pseudoaulacaspis pentagona* (Targioni Tozzetti)	Kuwayama 1962:365; Kosztarab and Kozár 1988:366	Polyphagous	PA or OR Rosen and DeBach 1978
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Chrysopa boninensis*)	Diaspididae	*Unaspis yanonensis* (Kuwana) (as *Prontaspis yanonensis*)	Kaburaki 1934:804; Ishii 1937: 69	Citrus	PA Rosen and DeBach 1978
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Chrysopa boninensis*)	Margarodidae	*Icerya purchasi* Maskell	Okamoto 1919:62	Fruit trees	AU Bartlett 1978
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Chrysopa boninensis* or *Chrysopa flavostigma*)	Margarodidae	*Icerya seychellarum* (Westwood)	Okamoto 1919:62; Vesey-Fitzgerald 1936:17	Polyphagous	AU(?) Bartlett 1978
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Mallada boninensis*)	Pseudococcidae	*Ferrisia virgata* (Cockerell)	Mani and Krishnamoorthy 1990b:122	Polyphagous	NT(?) Williams and Granara de Willink 1992
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Mallada boninensis*)	Pseudococcidae	*Maconellicoccus hirsutus* (Green)	Krishnamoorthy and Mani 1989:155; Mani 1989:162	Polyphagous	OR Williams 1996
Chrysopidae	*Mallada desjardinsi* (Navás) (as *Chrysopa* or *Mallada boninensis*)	Pseudococcidae	*Planococcus citri* (Risso) (some as *Dactylopius* or *Pseudococcus citri*)	Okamoto 1919:62; Krishamoorthy and Mani 1989:155; Mani and Krishamoorthy 1990b:122	Polyphagous	OR Bartlett 1978

Chrysopidae	*Mallada desjardinsi* (Navás) (as *Mallada boninensis*)	Pseudococcidae	*Planococcus lilacinus* (Cockerell)	Mani and Krishnamoorthy 1990b:122	Polyphagous	AF(?) Miller et al. 2002
Chrysopidae	*Mallada madestes* (Banks) (as *Chrysopa madestes*)	Kerriidae	*Kerria lacca* (Kerr)	Mehra 1965:398; Mishra et al. 1996:17	Polyphagous	OR Kapur 1958
Chrysopidae	*Plesiochrysa lacciperda* (Kimmins) (as *Chrysopa lacciperda*)	Pseudococcidae	*Ferrisia virgata* (Cockerell)	Krishnamoorthy and Mani 1989:155	Polyphagous	NT(?) Williams and Granara de Willink 1992
Chrysopidae	*Pleisochrysa lacciperda* (Kimmins) (as *Chrysopa lacciperda*)	Pseudococcidae	*Planococcus citri* (Risso)	Krishnamoorthy and Mani 1989:155; Mani and Krishnamoorthy 1990a:245; Mani and Krishnamoorthy 1990b:123	Polyphagous	OR Bartlett 1978
Chrysopidae	*Pleisochrysa ramburi* (Schneider) (as *Chrysopa ramburi*)	Coccidae	*Pulvinaria* sp.	McLachlan 1892:50	—	—
Chrysopidae	*Plesiochrysa ramburi* (Schneider) (as *Chrysopa ramburi*)	Pseudococcidae	*Dysmicoccus brevipes* (Cockerell) (as *Pseudococcus brevipes*)	Lever 1940:99	Polyphagous	NT Carter 1935
Chrysopidae	*Plesiochrysa ramburi* (Schneider) (as *Chrysopa ramburi*)	Pseudococcidae	*Pseudococcus calceolariae* (Maskell) (as *Pseudococcus gahani*)	Compere and Smith 1932:609	Polyphagous, including citrus	AU Bartlett 1978
Chrysopidae	*Plesiochrysa ramburi* (Schneider) (as *Chrysopa ramburi*)	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	Charles 1989:230	Polyphagous	AU Miller et al. 2005
Chrysopidae	*Semachrysa matsumurae* (Okamoto) (as *Chrysopa matsumurae*)	Margarodidae	*Icerya purchasi* Maskell	Okamoto 1919:67	Fruit trees	AU Bartlett 1978
Chrysopidae	*Semachrysa matsumurae* (Okamoto) (as *Chrysopa matsumurae*)	Margarodidae	*Icerya seychellarum* (Westwood)	Okamoto 1919:67	Polyphagous	AU(?) Bartlett 1978
Chrysopidae	*Semachrysa matsumurae* (Okamoto) (as *Chrysopa matsumurae*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Dactylopius citri*)	Okamoto 1919:67	Polyphagous	OR Bartlett 1978
Chrysopidae	*Suarius fedtschenkoi* (McLachlan in Fedtschenko)	Pseudococcidae	*Planococcus vovae* (Nasonov)	Lotfalizadeh and Ahmadi 2000: 149	Cypress	PA Miller et al. 2002
Coniopterygidae	*Aleuropteryx juniperi* Ohm	Diaspididae	*Carulaspis juniperi* (Bouché)	Ward 1970:77; Henry 1976:196; Wheeler 1981:173	Conifers, especially junipers	PA Balachowsky 1954
Coniopterygidae	*Aleuropteryx juniperi* Ohm	Diaspidiae	*Carulaspis minima* (Targioni Tozzetti)	Henry 1976:196; Stimmel 1979: 227; De Marzo and Pantaleoni 1998:11	Conifers, especialy junipers, cypres	PA Gill 1997
Coniopterygidae	*Aleuropteryx loewii* Klapálek	Diaspididae	*Leucaspis pini* (Hartig)	Enderlein 1906:185	Pines	PA Balachowsky 1953
Coniopterygidae	*Aleuropteryx loewii* Klapálek	Diaspididae	*Nuculaspis abietus* (Schrank) (as *Aspidiotus abietis*)	Enderlein 1906:185	Conifers	PA Balachowsky 1948
Coniopterygidae	*Aleuropteryx simillima* Meinander	Diaspididae	*Carulaspis minima* (Targioni Tozzetti)	Wheeler 1980:51	Conifers, especially junipers, cypress	PA Gill 1997
Coniopterygidae	*Coniopteryx pygmaea* Enderlein	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Coniopterygidae	*Coniopteryx* sp.	Diaspididae	*Aonidiella citrina* (Coquillett)	Fleschner and Ricker 1953:459; Drea 1990:52	Citrus	OR McKenzie 1938
Conipterygidae	*Conwentzia barretti* (Banks) (some as *Parasemidalis flaviceps*)	Diaspididae	*Aonidiella citrina* (Coquillett)	Fleschner and Ricker 1953:459; Drea 1990:52	Cirtus	OR McKenzie 1938
Coniopterygidae	*Conwentzia californica* Meinander (?) (as "*Conwentzia nigrans* Carpenter", nomen nudum, see Drea 1990:53)	Diaspididae	*Aonidiella citrina* (Coquillett)	Fleshner and Ricker 1953:459; Drea, 1990:52	Citrus	OR McKenzie 1938

Table 1. Continued

Neuropterida family	Neuropterida species (predator)	Coccoidea family	Scale species (prey)	Predator/prey association reference	Principal scale hosts	Scale origin and reference
Coniopterygidae	*Conwentzia pineticola* Enderlein (as *Conwentzia hageni*)	Coccidae	*Parasaissetia nigra* (Nietner) (as *Saissetia nigra*)	Smith 1944:275	Polyphagous	AF or OR Gill 1988
Coniopterygidae	*Conwentzia pineticola* Enderlein	Diaspididae	*Chrysomphalus aonidum* (Linnaeus) (as *Chrysomphalus ficus*)	Priesner and Hosny 1940:64	Polyphagous	OR Rosen and DeBach 1978
Coniopterygidae	*Conwentzia pineticola* Enderlein	Diaspididae	*Fiorinia externa* Ferris	McClure 1979:869	Hemlock	PA Murakami 1970
Coniopterygidae	*Conwentzia psociformis* (Curtis)	Coccidae	*Lichtensia viburni* Signoret	Killington 1936:156	Polyphagous	PA Kosztarab and Kozár 1988
Coniopterygidae	*Conwentzia psociformis* (Curtis)	Diaspididae	*Aonidiella aurantii* (Maskell) (as *Chrysomphalus aurantii*)	Bodenheimer 1934:146	Polyphagous	OR Rosen and DeBach 1978
Coniopterydae	*Conwentzia psociformis* (Curtis)	Diaspididae	*Chionaspis salicis* (Linnaeus)	Withycombe 1923:580	Polyphagous, *Salix*, *Populus*	PA
Coniopterygidae	*Conwentzia psociformis* (Curtis)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus) (as *Chrysomphalus ficus*)	Priesner and Hosny 1940:64	Polyphagous	OR Rosen and DeBach 1978
Coniopterygidae	*Conwentzia psociformis* (Curtis) (some as *Coniopteryx psociformis*)	Pseudococcidae	*Maconellicoccus hirsutus* (Green) (as *Phenacoccus hirsutus*)	Hall 1921:24; Priesner and Hosny 1940:64; Mani 1989: 162	Polyphagous	OR Williams 1996
Coniopterygidae	*Cryptoscenea australiensis* (Enderlein)	Pseudococcidae	*Balanococcus* sp. (some as *Trionymus* sp.)	Kimmins and Wise 1962:36; Charles 1989:227	—	—
Coniopterygidae	*Cryptoscenea australiensis* (Enderlein)	Pseudococcidae	*Pseudococcus calceolariae* (Maskell)	Charles 1998:227	Polyphagous, including citrus	AU Bartlett 1978
Coniopterygidae	*Cryptoscenea australiensis* (Enderlein)	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozetti)	Charles 1989:227	Polyphagous	AU Miller et al. 2002
Coniopterygidae	*Cryptoscenea australiensis* (Enderlein)	Pseudococcidae	*Pseudococcus viburni* (Signoret) (as *Pseudococcus affinis*)	Charles 1989:227	Polyphagous	NE Miller et al. 2005
Coniopterygidae	*Helicoconis lutea* (Wallengren)	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Coniopterygidae	*Heteroconis picticornis* (Banks) (as *Spiloconis picticornis*)	Coccidae	*Coccus hesperidum* Linnaeus	Badgley et al. 1955:75	Polyphagous	OR Miller and Miller 2003
Coniopterygidae	*Heteroconis picticornis* (Banks) (as *Spiloconis picticornis*)	Diaspididae	*Aonidiella aurantii* (Maskell)	Badgley et al. 1955:75	Citrus	OR McKenzie 1938
Coniopterygidae	*Heteroconis picticornis* (Banks) (as *Spiloconis picticornis*)	Diaspididae	*Aspidiotus nerii* Bouché (as *Aspidiotus hederae*)	Badgley et al. 1955:81	Polyphagous	AU? Ferris 1941 or AF? Balachowsky 1948
Coniopterygidae	*Heteroconis picticornis* (Banks) (as *Spiloconis picticornis*)	Diaspididae	*Hemiberlesia lataniae* (Signoret) (as *Aspidiotus lataniae*)	Clausen 1956:126	Polyphagous	uncertain Gill 1997
Coniopterygidae	*Heteroconis picticornis* (Banks)	Diaspididae	*Lepidosaphes* sp.	Muma et al. 1975[b]	—	—
Coniopterygidae	*Heteroconis picticornis* (Banks) (as *Spiloconis picticornis*)	Diaspididae	*Pseudaulacaspis pentagona* (Targioni Tozzetti)	Bennett and Hughes 1959:425	Polyphagous	PA or OR Rosen and DeBach 1978
Coniopterygidae	*Semidalis aleyrodiformis* (Stephens)	Diaspididae	*Carulaspis* sp.	Bennett and Hughes 1959:427	—	—
Coniopterygidae	*Semidalis aleyrodiformis* (Stephens)	Diaspididae	*Chionaspis salicis* (Linnaeus)	Withycombe 1923:588	Polyphagous, *Salix, Populus*	PA
Coniopterygidae	*Semidalis pseudouncinata* Meinander	Diaspididae	*Carulaspis minima* (Targioni Tozzetti)	De Marzo and Pantaleoni 1998:11	Conifers, especially junipers, cypress	PA Gill 1997
Coniopterygidae	*Semidalis vicina* (Hagen)	Coccidae	*Parthenolecanium* sp.	Miller and Williams 1985:81	—	—
Coniopterygidae	*Semidalis vicina* (Hagen)	Diaspididae	*Chrysomphalus aonidum* (Linnaeus)	Muma et al. 1975[b]	Polyphagous	OR Rosen and DeBach 1978

Coniopterygidae	*Semidalis vicina* (Hagen)	Diaspididae	*Lepidosaphes beckii* (Newman)	Muma et al. 1975[b]	Polyphagous, citrus	OR Gill 1997
Hemerobiidae	*Hemerobius micans* Olivier	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Meier 1948:84	Fruit trees and ornamental plants	PA Bartlett 1978
Hemerobiidae	*Hemerobius nitidulus* Fabricius	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederling 1980:340	—	—
Hemerobiidae	*Hemerobius pacificus* Banks	Coccidae	*Parasaissetia nigra* (Nietner) (as *Saissetia nigra*)	Smith 1944:275	Polyphagous	AF or OR Gill 1988
Hemerobiidae	*Hemerobius pacificus* Banks	Diaspididae	*Hemiberlesia lataniae* (Signoret)	Ebeling 1959:297	Polyphagous	uncertain Gill 1997
Hemerobiidae	*Hemerobius pacificus* Banks	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	DeBach 1949:17; DeBach et al. 1949:777	Polyphagous	AU Miller et al. 2002
Hemerobiidae	*Hemerobius pini* Stephens	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Hemerobiidae	*Hemerobius simulans* Walker	Margarodidae	*Matsucoccus feytaudi* Ducasse	Covassi et al. 1991:579	Pines	PA Riom et al. 1971
Hemerobiidae	*Hemerobius stigma* Stephens (as *Hemerobius stigmaterus*)	Coccidae	*Mesolecanium nigrofasciatum* (Pergande) (as *Eulecanium nigrofasciatum*)	Simanton 1916:63	Deciduous fruit trees	NE
Hemerobiidae	*Hemerobius stigma* Stephens	Margarodidae	*Matsucoccus feytaudi* Ducasse	Covassi et al. 1991:579	Pines	PA Riom et al. 1971
Hemerobiidae	*Hemerobius stigma* Stephens	Margarodidae	*Matsucoccus josephi* Bodenheimer and Harpaz	Branco et al. 2002 (2001):397	Pines	PA Mendel et al. 1990
Hemerobiidae	*Hemerobius stigma* Stephens (as *Hemerobius stigmaterus* or *stigmatus* [sic])	Margarodidae	*Matsucoccus matsumurae* (Kuwana) (some as *Matsucoccus resinosae*)	Bean and Godwin 1955:175; Kosztarab 1996:48	Pines	PA McClure 1983
Hemerobiidae	*Hemerobius stigma* Stephens (as *Hemerobius stigmaterus*)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Hough 1925:25; Haeussler and Clancy 1944:507	Fruit trees and ornamental plants	PA Bartlett 1978
Hemerobiidae	*Hemerobius stigma* Stephens	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Hemerobiidae	*Hemerobius* sp.	Eriococcidae	*Cryptococcus fagisuga* Lindinger (as *Cryptococcus fagi*)	Schindler 1962[b]	*Fagus* spp.	PA Ehrlich 1932
Hemerobiidae	*Megalomus balachowskyi* Lestage	Pseudococcidae	*Nipaecoccus nipae* (Maskell) (as *Pseudococcus nipae*)	Lestage 1928:154	Polyphagous	NT Miller et al. 2005
Hemerobiidae	*Micromus tasmaniae* (Walker)	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	Charles 1989:227	Polyphagous	AU Miller et al. 2002
Hemerobiidae	*Sympherobius amiculus* (Fitch)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Haeussler and Clancy 1944:507	Fruit trees and ornamental plants	PA Bartlett 1978
Hemerobiidae	*Sympherobius amiculus* (Fitch)	Pseudococcidae	*Pseudococcus maritimus* (Ehrhorn)	Neiswander 1949:42	Fruit trees and ornamental plants	PA Bartlett 1978
Hemerobiidae	*Sympherobius angustus* (Banks)	Coccidae	*Ceroplastes* sp.	Banks 1905:41	—	—
Hemerobiidae	"*Sympherobius angustus*" (Banks) (possible misidentification of *Sympherobius californicus* Banks)	Diaspididae	*Aonidiella aurantii* (Maskell) (as *Chrysomphalus aurantii*)	Essig 1915:184	Citrus	OR McKenzie 1938
Hemerobiidae	"*Sympherobius angustus*" (Banks) (possible misidentification of *Sympherobius californicus* Banks)	Diaspididae	*Lepidosaphes beckii* (Newman)	Essig 1915:188	Polyphagous, citrus	OR Gill 1997
Hemerobiidae	*Sympherobius angustus* (Banks)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Cole 1933:859	Polyphagous	PA Cox 1989
Hemerobiidae	"*Sympherobius angustus*" (Banks) (probable misidentification of *Sympherobius barberi* (Banks)	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti) (as *Pseudococcus adonidum*)	Ebeling 1959:181	Polyphagous	PA Cox 1989
Hemerobiidae	*Sympherobius barberi* (Banks)	Coccidae	*Pulvinaria psidii* Maskell	Bartlett 1978:66	Polyphagous	OR(?) Miller and Miller 2003

Table 1. Continued

Neuropterida family	Neuropterida species (predator)	Coccoidea family	Scale species (prey)	Predator/prey association reference	Principal scale hosts	Scale origin and reference
Hemerobiidae	*Sympherobius barberi* (Banks)	Pseudococcidae	*Antonina graminis* Maskell	Riherd and Chada 1952:2	Grass	OR Chada and Wood 1960
Hemerobiidae	*Sympherobius barberi* (Banks)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Smith and Armitage 1920:109; Cole 1933:859	Polyphagous	OR Bartlett 1978
Hemerobiidae	*Sympherobius barberi* (Banks)	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti) (as *Pseudococcus adonidum*)	Bennett and Hughes 1959:430	Polyphagous	AU Miller et al. 2002
Hemerobiidae	*Sympherobius barberi* (Banks)	Pseudococcidae	*Pseudococcus maritimus* (Ehrhorn)	Smith and Armitage 1920:111	Polyphagous	NE Miller et al. 2002
Hemerobiidae	*Sympherobius californicus* Banks	Pseudococcidae	*Paracoccus solani* Ezzat and McConnell (as *Gossypina glauca*)	Aguilar F. and Lamas C. 1980: 91	Polyphagous	NE or NT Williams and Granara de Wilink 1992
Hemerobiidae	*Sympherobius californicus* Banks	Pseudococcidae	*Phenacoccus gossypii* Townsend and Cockerell	Aguilar F. and Lamas C. 1980: 91	Polyphagous	NE Miller et al. 2002
Hemerobiidae	*Sympherobius californicus* Banks	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Smith and Armitage 1920:109; Cole 1933:859	Polyphagous	OR Bartlett 1978
Hemerobiidae	*Sympherobius californicus* Banks (as *Sympherobius angustus*; misidentification, see Oswald 1988:423)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Essig 1910:143	Polyphagous	PA Cox 1989
Hemerobiidae	*Sympherobius californicus* Banks	Pseudococcidae	*Planococcus kraunhiae* (Kuwana) (as *Pseudococcus kraunhiae*)	Smith and Armitage 1920:112	Polyphagous	PA Cox 1989
Hemerobiidae	*Sympherobius californicus* Banks	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	DeBach and Fleschner 1947:3; DeBach 1949:17; DeBach et al. 1949:777	Polyphagous	AU Miller et al. 2002
Hemerobiidae	*Sympherobius californicus* Banks	Pseudococcidae	*Pseudococcus maritimus* (Ehrhorn)	Smith and Armitage 1920:111; Doutt and Hagen 1950:95	Polyphagous	NE Miller et al. 2002
Hemerobiidae	*Sympherobius californicus* Banks	Pseudococcidae	*Pseudococcus neomaritimus* Beardsley	Aguilar F. and Lamas C. 1980: 91	Tropical plants	Pacific Isl. Gimpel and Miller 1996
Hemerobiidae	*Sympherobius domesticus* Nakahara	Pseudococcidae	*Phenacoccus pergandei* Cockerell	Kuwayama 1962:359	Polyphagous	PA
Hemerobiidae	*Sympherobius domesticus* Nakahara	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Murakami 1963:233	Polyphagous	PA Bartlett 1978
Hemerobiidae	*Sympherobius elegans* (Stephens)	Coccidae	*Parthenolecanium corni* (Bouché)	Kawecki 1958:199	Polyphagous	PA Miller and Miller 2003
Hemerobiidae	*Sympherobius elegans* (Stephens)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Ruiz Castro 1942:184	Polyphagous	OR Bartlett 1978
Hemerobiidae	*Sympherobius elegans* (Stephens)	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Hemerobiidae	*Sympherobius fallax* Navás (as *Sympherobius sanctus*)	Coccidae	*Saissetia oleae* (Olivier)	Argov and Rössler 1993:90	Polyphagous	AF Bartlett 1978
Hemerobiidae	*Sympherobius fallax* Navás (as *Nefasitus fallax*)	Pseudococcidae	*Maconellicoccus hirsutus* (Green) (as *Phenacoccus hirsutus*)	Priesner and Hosny 1940:64	Polyphagous	OR Williams 1996
Hemerobiidae	*Sympherobius fallax* Navás	Pseudococcidae	*Phenacoccus madeirensis* Green	Sinacori and Tsolakis 1994:40	Polyphagous	NT Miller et al. 2002
Hemerobiidae	*Sympherobius fallax* Navás (as *Nefasitus fallax* or *Sympherobius amicus*)	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Klein and Perzelan 1940:109; Ruiz Castro 1942:184; Rivnay 1943:76	Polyphagous	OR Bartlett 1978
Hemerobiidae	*Sympherobius fallax* Navás (as *Sympherobius amicus*)	Pseudococcidae	*Pseudococcus calceolariae* (Maskell) (as *Pseudococcus gahani*)	Tshotshia 1941[b]	Polyphagous, including citrus	AU Bartlett 1978

Hemerobiidae	*Sympherobius fallax* Navás (as *Sympherobius amicus*)	Pseudococcidae	*Pseudococcus comstocki* (Kuwana)	Klein and Perzelan 1940:109; Rivnay 1943:58; Kamenkova 1948:102	Fruit trees and ornamental plants	PA Bartlett 1978
Hemerobiidae	*Sympherobius fallax* Navás (as *Sympherobius sanctus*)	Pseudococcidae	*Pseudococcus cryptus* Hempel	Blumberg et al. 1999:235	Polyphagous	NT(?) Miller et al. 2002
Hemerobiidae	*Sympherobius fallax* Navás (or *Sympherobius sanctus*)	Pseudococcidae	*Pseudococcus longispinus* (Targioni Tozzetti)	Swirski et al. 1980:422; Gillani and Copland 1999:280	Polyphagous	AU Miller et al. 2002
Hemerobiidae	*Sympherobius pygmaeus* (Rambur)	Diaspididae	*Chionaspis salicis* (Linnaeus)	Withycombe 1923:528	Polyphagous, *Salix*, *Populus*	PA
Hemerobiidae	*Sympherobius pygmaeus* (Rambur)	Margarodidae	*Matsucoccus josephi* Bodenheimer and Harpaz	Bodenheimer and Neumark 1955:83	Pines	PA Mendel et al. 1990
Hamerobiidae	*Sympherobius pygmaeus* (Rambur) (some as *Mucropalpus pygmaeus*)	Pseudococcidae	*Maconellicoccus hirsutus* (Green) (some as *Phenacoccus hirsutus*)	Hall 1921:24; Mani 1989:162	Polyphagous	OR Williams 1996
Hamerobiidae	*Sympherobius pygmaeus* (Rambur) (as *Sympherobius luqueti*)	Pseudococcidae	*Phenacoccus madeirensis* Green	Sinacori and Tsolakis 1994:40	Polyphagous	PA
Hemerobiidae	*Sympherobius pygmaeus* (Rambur) (some as *Sympherobius conspersus*)	Pseudococcidae	*Planococcus citri* (Risso) (some as *Pseudococcus citri*)	Zinna 1960:259; Ruiz Castro 1942:184	Polyphagous	OR Bartlett 1978
Hemerobiidae	*Sympherobius pygmaeus* (Rambur)	Pseudococcidae	*Planococcus ficus* (Signoret)	Dalla Montá et al 2002 (2001): 345	Polyphagous, incuding grapes	PA Cox 1989
Hemerobiidae	*Sympherobius pygmaeus* (Rambur)	Pseudococcidae	*Trabutina mannipara* (Hemrich and Enrenberg)	Monaco 1977:161	*Tamarix* spp.	PA Danzig and Miller 1996
Hemerobiidae	*Sympherobius tessellatus* Nakahara (as *Sympherobius weisong*)	Margarodidae	*Matsucoccus massonianae* Young and Hu	Wang 1984:96	Pines	PA
Hemerobiidae	*Sympherobius tesselatus* Nakahara (some as *Sympherobius weisong*)	Margarodidae	*Matsucoccus matsumurae* Kuwana	Kuwayama 1962:359; Wang 1984:96	Pines	PA McClure 1983
Hemerobiidae	*Sympherobius tessellatus* Nakahara (as *Sympherobius weisong*)	Margarodidae	*Matsucoccus sinensis* Chen	Wang 1984:96	Pines	PA
Hemerobiidae	*Sympherobius* sp.	Dactylopiidae	*Dactylopius coccus* Costa	Portillo and Vigueras 1998[b]	Cactus	NE Delotto 1974
Hemerobiidae	*Sympherobius* sp.	Eriococcidae	*Eriococcus spurius* (Modeer) (as *Gossyparia spuria*)	Khersonskaya 1962[b]	Elm	PA Kosztarab 1996
Hemerobiidae	*Sympherobius* sp.	Pseudococcidae	*Planococcus citri* (Risso) (as *Pseudococcus citri*)	Shutova and Kukhatina 1955:217	Polyphagous	OR Bartlett 1978
Hemerobiidae	*Sympherobius* sp (?) (as "*Sympherobius pacificus*"; no such species; probably a misidentification of a *Sympherobius* sp.; *Hemerobius pacificus* not known from Peru)	Pseudococcidae	*Planococcus citri* (Risso)	Aguilar F. et al. 1980b:98	Polyphagous	OR Bartlett 1978
Hemerobiidae	*Wesmaelius quadrifasciatus* (Reuter) (as *Wesmaelius 4-fasciatus* [sic])	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Hemerobiidae	*Wesmaelius subnebulosa* (Stephens) (as *Boriomyia subnebulosa*)	Coccidae	*Pulvinaria vitis* (Linnaeus) (as *Pulvinaria betulae*)	Withycombe 1923:542	Polyphagous	PA Hodgson 1994
Inocellidae	*Parainocellia bicolor* (Costa) (as *Inocellia bicolor*)	Margarodidae	*Matsucoccus feytaudi* Ducasse	Covassi et al. 1991:579	Pines	PA Riom et al. 1971
Raphidiidae	*Agulla astuta* (Banks)	Coccidae	*Saissetia oleae* (Olivier)	Woglum and McGregor 1959: 489	Polyphagous	AF Bartlett 1978

Table 1. Continued

Neuropterida family	Neuropterida species (predator)	Coccoidea family	Scale species (prey)	Predator/prey association reference	Principal scale hosts	Scale origin and reference
Raphidiidae	*Agulla bractea* Carpenter	Coccidae	*Saissetia oleae* (Olivier) (as "black scale")	Woglum and McGregor 1958:129	Polyphagous	AF Bartlett 1978
Raphidiidae	*Dichrostigma flavipes* (Stein) (as *Raphidia flavipes*)	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Raphidiidae	*Phaeostigma notatum* (Fabricius) (as *Raphidia notata*)	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—
Raphidiidae	*Xanthostigma xanthostigma* (Schummel) (*Raphidia xanthostigma*)	Pseudococcidae	*Pseudococcus* sp.	Eglin-Dederding 1980:340	—	—

AF, Afrotropical region; AU, Australasian region; NE, Nearctic region; OR, Oriental region; PA, Palearctic region.

[a] "*Brinckochrysa scelestes* (Banks)": Singh and Narasimham 1992:14 (footnote) indicated that the identity of the chrysopid frequently cited in the Indian biological control literature as *Brinckochrysa scelestes* (Banks) (or earlier, *Chrysopa scelestes*) required confirmation.

[b] Reference not seen but cited in another reference.

[c] "*Chrysopa* sp.": Many literature references to "*Chrysopa* sp." as scale insect predators probably pertain to chrysopid species that would not now be placed in the modern restricted sense of the genus *Chrysopa*. The former concept of a very large (≥750 spp.), cosmopolitan, genus *Chrysopa* s. lat. has been extensively modified from the mid 1960's on, with many new genera having been erected to hold many of its former species. Because of the difficulty of identifying chrysopids to species level (which usually requires detailed examination of male terminalic characters) and the difficulty of properly reassigning species to new genera (a process that is still on going), many workers, particularly nonsystematists, have persisted in using the generic name *Chrysopa* in a broad sense to cover almost any small green chrysopid. Although this situation is slowly changing as nonsystematists become more familiar with modern generic concepts in the Chrysopidae (see Brooks and Barnard 1990)—particularly with the concept of the genus *Chrysoperla* which contains many of the most economically important green lacewing species—some recent workers have yet to adopt scientific names for chrysopid species that are fully consistent with modern taxonomic practice.

[d] "*Chrysoperla carnea* (Stephens)": The taxonomic entity that has been known for many years as *Chrysoperla carnea* (or earlier, *Chrysopa carnea*) has been shown over the past 25 yr to be a complex of sibling and near-sibling species that are largely, if not entirely, reproductively isolated under natural conditions due to their production of distinctive abdominal tremulation patterns during courtship. Males and females engage in tremulation duets that permit them to identify conspecific individuals and to preferentially mate with members of the same "song species." The *Chrysoperla carnea* species complex is now known to contain at least 15 partially or fully cryptic song species, including 7 in North America, 5 in Europe, and 3 in Asia. The correct scientific names that should be associated with these species are still being worked out. Given the wide geographic range of the records represented in the table above as "*Chrysoperla carnea*," it is almost certain that these records in fact represent more than one of the *Chrysoperla carnea* complex song species.

doubtedly some references that have been excluded. The following data on associations were recorded from the literature: (1) scientific name and family of predator (neuropterid) species, (2) scientific name and family of prey (coccoid) species, and (3) bibliographic citation information. Associations were recorded only if both predator and prey taxa were identified at least to genus, i.e., associations in which either the predator or the prey taxon was identified only to family or order rank were excluded. Associations in which both predator and prey taxa were identified only to genus (<1% of identified associations) were included only if they involved genera that would otherwise be absent from the matrix of known predator/prey associations (e.g., the association of *Ankylopteryx* sp. [predator] and *Pulvinaria* sp. [prey]).

After the initial compilation of predator/prey associations, the scientific names and family associations of all nominal taxa were checked for accuracy, and appropriate taxonomic/nomenclatural changes were recorded. Known or suspected misidentifications were also noted. For each scale taxon identified to species level, we also accumulated data on principal host plants and known or suspected region of origin. Scale origin records were based primarily on Miller et al. (2002, 2005) and Miller and Miller (2003). Scale origins not recorded in these references were based on statements in other literature, the known distributions of geographically restricted congeners, or, failing these, a variety of other more speculative factors.

Results

This study identified 263 distinct predator/prey associations between neuropterid and coccoid insects (Table 1). These associations involve 35 genera and 82 identified neuropterid species and 52 genera and 91 identified coccoid species. Within the Neuropterida (Table 2), taxa in three families predominate: Chrysopidae—18 genera (51% of neuropterid genera) and 43 species (52% of neuropterid species); Hemerobiidae—5 genera (14%) and 19 species (23%); and Coniopterygidae—7 genera (20%) and 14 species (17%). Among the Coccoidea (Table 3), taxa in three families also predominate: Pseudococcidae—13 genera (25% of coccoid genera) and 28 species (31% of coccoid species); Diaspididae—18 genera (35%) and 24 species (26%); and Coccidae—11 genera (21%) and 22 species (24%). As foreshadowed by these data, a large majority of the documented predator/prey associations (221, 84%) is between species in these six families (Table 4). Grouped by neuropteran family, 60% of all associations involve the family Chrysopidae, 25% the Hemerobiidae, and 13% the Coniopterygidae. Grouped by coccoid family, 45% of all associations involve the Pseudococcidae, 25% the Diaspididae, and 16% the Coccidae. Species in other neuropterid and coccoid families accounted for only 16% of known associations. Two neuropteran families show a clear majority of associations with a single coccoid family: Hemerobiidae with Pseudococcidae (66% of hemerobiid associations) and Coniopterygidae with Diaspididae (68% of coniopterygid associations). The family Chrysopidae showed the broadest range of associations with coccoid families, but a distinct plurality (41%) of its associations were with the family Pseudococcidae.

Table 2. Numbers of neuropterid taxa with known neuropterid/coccoid predator/prey associations

Family	Genera	Species
Chrysopidae	18	43
Hemerobiidae	5	19
Conioptery gidae	7	14
Raphidiidae	4	5
Inocellidae	1	1
Totals	35	82

Table 3. Numbers of coccoid taxa with known neuropterid/coccoid predator/prey associations

Family	Genera	Species
Pseudococcidae	13	28
Diaspididae	18	24
Coccidae	11	22
Margarodidae	4	11
Eriococcidae	2	2
Kerridae	2	2
Dactylopiidae	1	1
Ortheziidae	1	1
Totals	52	91

Prey diversity for neuropterid predators is summarized in Table 5. In addition to the number of coccoid prey species recorded for various neuropterid species (Table 5, column 2), the number of coccoid prey species (as percent) known for those neuropterid species within their respective family is also recorded (Table 5, column 3). Among chrysopids, the greatest prey diversity was recorded for "*Chrysoperla carnea*" and "*Chrysopa*" sp. Each of these taxon categories were reported as predators of >25% of the total number of scale species recorded as prey for all chrysopid species. One additional species—*Chrysoperla plorabunda*—was reported as a predator of >15% of all chrysopid scale-prey species. Four hemerobiid species (*Sympherobius californicus*, *Sympherobius fallax*, *Sympherobius pygmaeus*, and *Hemerobius stigma*) and three coniopterygid species (*Heteroconis picticornis*, *Conwentzia psociformis*, and *Cryptoscenea australiensis*) were also recorded as predators of >15% of the total number scale-prey species recorded for their respective families. However, large majorities of species in all three families—Chrysopidae, 93%; Hemerobiidae, 79%; and Coniopterygidae, 79%—were found to be predators of <15% of the total number of prey species reported for their respective families.

Predator diversity for coccoid prey species is summarized in Table 6. Five scale families had one or more species preyed on by three or more neuropterid species: Pseudococcidae, Diaspididae, Coccidae, Margarodidae, and Eriococcidae. The following scale taxa supported the highest diversity of predators (10 or more recorded predator species each): *Planococcus citri* (Pseudococcidae, 19 predator species), *Pseudo-*

Table 4. Family-level distribution of known neuropterid/coccoid predator/prey association

Neuropterid family	Coccoid family [no. associations (percent of associations within neuropterid family)]								Association totals
	Pse	Dia	Coc	Mar	Eri	Ker	Dac	Ort	No. (% of all)
Chrysopidae	65 (41)	40 (25)	28 (18)	18 (11)	3 (2)	3 (2)	—	1 (<1)	158 (60)
Hemerobiidae	43 (66)	4 (6)	7 (11)	8 (12)	2 (3)	—	1 (2)	—	65 (25)
Coniopterygidae	7 (21)	23 (68)	4 (12)	—	—	—	—	—	34 (13)
Raphidiidae	3 (60)	—	2 (40)	—	—	—	—	—	5 (2)
Inocelliidae	—	—	—	1 (100)	—	—	—	—	1 (<1)
Totals: no. (%)	118 (45)	67 (25)	41 (16)	27 (10)	5 (2)	3 (1)	1 (<1)	1 (<1)	263 (100)

Pse, Pseudococcidae; Dia, Diaspididae; Coc, Coccidae; Mar, Margarodidae; Eri, Eriococcidae; Ker, Kerriidae; Dac, Dactylopiidae; Ort, Ortheziidae.

coccus sp. (Pseudococcidae, 14), *Chrysomphalus aonidum* (Diaspididae, 13), and *Pseudococcus comstocki* (Pseudococcidae, 12). Seven additional species in four families (Table 6) are known to be prey for five to nine neuropterid species each.

The distribution of neuropterid/coccoid association records organized by principal scale host class is given in Table 7. A majority of associations for the families Chrysopidae (66%), Hemerobiidae (58%), and Coniopterygidae (50%) involve polyphagous scale species. The families Coniopterygidae (21%) and Hemerobiidae (14%) show a substantially greater proportion, relative to Chrysopidae (4%), of associations with scales found primarily on coniferous hosts. Overall, 62% of associations involved polyphagous scale species, 9% involved scale species primarily associated with coniferous hosts, and 21% involved nonpolyphagous, nonconiferous-associated, scale species (these species were primarily associates of woody dicots).

Table 5. Neuropterid predator taxa with three or more recorded coccoid prey species

Family and species	No. coccoid prey species	% neuropterid family prey species
Chrysopidae	**74**	
*"Chrysoperla carnea"**	27	36
"Chrysopa" sp.*	21	28
Chrysoperla plorabunda	11	15
Mallada desjardinsi	9	12
Dichochrysa prasina	7	9
Mallada anpingensis	5	7
Chrysopa pallens	4	5
Chrysoperla rufilabris	4	5
Cunctochrysa albolineata	4	5
Dichochrysa aegyptiaca	4	5
Plesiochrysa ramburi	4	5
Ceraeochrysa cubana	3	4
Chrysopa nigricornis	3	4
Semachrysa matsumurae	3	4
Hemerobiidae	**36**	
Sympherobius californicus	8	22
Sympherobius fallax	8	22
Sympherobius pygmaeus	7	19
Hemerobius stigma	6	17
Sympherobius barberi	5	14
Hemerobius pacificus	3	8
Sympherobius elegans	3	8
Sympherobius tessellatus	3	8
Coniopterygidae	**22**	
Heteroconis picticornis	6	27
Conwentzia psociformis	5	23
Cryptoscenea australiensis	4	18
Conwentzia pineticola	3	14
Semidalis vicina	3	14

* See the footnotes regarding these taxa at the end of Table 1. Numbers in bold represent the total number of coccoid prey species of the included neuropterid families from Table 1. Column three reflects the number of coccoid prey species (as percent) known for those neuropterid species within their respective family.

Table 6. Coccoid prey taxa with three or more recorded neuropterid predator species

Coccoid family and species	No. predator species	% coccoid family predator species	Predator families
Pseudococcidae	**53**		
Planococcus citri	19	36	Chr, Hem
Pseudococcus sp.	14	26	Chr, Con, Hem, Rap
Pseudococcus comstocki	12	23	Chr, Hem
Maconellicoccus hirsutus	9	17	Chr, Con, Hem
Pseudococcus longispinus	9	17	Chr, Con, Hem
Pseudococcus maritimus	7	13	Chr, Hem
Ferrisia virgata	5	9	Chr
Pseudococcus calceolariae	4	8	Chr, Con, Hem
Phenacoccus gossypii	3	6	Chr, Hem
Phenacoccus madeirensis	3	6	Chr, Hem
Diaspididae	**34**		
Chrysomphalus aonidum	13	38	Chr, Con
Lepidosaphes beckii	5	15	Chr, Con, Hem
Aonidiella aurantii	4	12	Chr, Con, Hem
Diaspidiotus perniciosus	4	12	Chr
Fiorinia theae	4	12	Chr
Aonidiella citrina	3	9	Con
Aulacaspis citri	3	9	Chr
Carulaspis minima	3	9	Con
Chionaspis salicis	3	9	Con, Hem
Hemiberlesia lataniae	3	9	Chr, Con, Hem
Unaspis yanonensis	3	9	Chr
Coccidae	**24**		
Saissetia oleae	6	25	Chr, Hem, Rap
Pulvinaria vitis	4	16	Chr, Hem
Parasaissetia nigra	3	13	Chr, Con, Hem
Margarodidae	**17**		
Icerya purchasi	5	29	Chr
Matsucoccus matsumurae	4	24	Chr, Hem
Matsucoccus feytaudi	3	18	Hem, Ino
Marsucoccus josephi	3	18	Chr, Hem
Eriococcidae	**5**		
Cryptococcus fagisuga	3	60	Chr, Hem

Numbers in bold represent the total number of neuropterid predator species of the included coccoid families from Table 1. Column three respects the number of coccoid predator species (as percent) known for those coccoid species within their respective family.

Chr, Chrysopidae; Con, Coniopterygidae; Hem, Hemerobiidae; Ino, Inocelliidae; Rap, Raphidiidae.

Table 7. Distribution of neuropterid/coccoid predator/prey associations by neuropterid family and principal scale host

Neuropterid family	Principal scale hosts [no. of associations (percent of associations within neuropterid family)]				Association totals
	Polyphagous	Conifers	Other	Unknown	No. (% of all)
Chrysopidae	105 (66)	7 (4)	39 (25)	7 (4)	158 (60)
Hemerobiidae	38 (58)	9 (14)	12 (18)	6 (9)	65 (25)
Coniopterygidae	17 (50)	7 (21)	4 (12)	6 (18)	34 (13)
Raphidiidae	2 (40)	—	—	3 (60)	5 (2)
Inocelliidae	—	1 (100)	—	—	1 (<1)
Totals: no. (%)	162 (62)	24 (9)	55 (21)	22 (8)	263 (100)

Principal scale host classes: Polyphagous; Conifers; Other, mostly woody dicots; Unknown.

Eight percent of associations involved scales whose host relationships were insufficiently known to be placed in one of the three preceding classes.

Table 8 gives the distribution of neuropterid/coccoid associations organized by neuropterid family and putative region of scale origin. For all three neuropteran families with ≥30 documented associations (Chrysopidae, Hemerobiidae, and Coniopterygidae), scales originating in the Palearctic and Oriental regions predominate. Scales originating in these regions together account for 59–62% of all associations for these three families. Scales originating in other regions account individually for ≤11% of the associations of scales whose origins are known or reasonably inferred.

Discussion

The data compiled here present a view of neuropterid/coccoid predator/prey associations strongly biased toward species commonly found in managed agricultural ecosystems. This conclusion is clear from a casual scan of the References and is further reinforced by the observation that the species listed in Tables 5 and 6 include many of the most serious scale pests of agriculture and many of the neuropterid predators most frequently encountered in agricultural situations. Little information is available in the literature concerning the predator/prey associations of neuropterids and coccoids in natural or near-natural settings, a fact that influences our perception of the true diversity of such associations and diminishes our ability to draw from the full range of these associations for use in biological control efforts.

While recognizing the limitations of these data, we would like to note several general observations regarding them.

Margarodid Associations. The number of associations (26, 10% of all associations) between neuropterids (Chrysopidae and Hemerobiidae) and margarodid scales at first seems disproportionately high relative to the small species diversity of the family Margarodidae. Part of this may be explained given the long history of research on *Icerya purchasi*. A serious scale pest of fruit trees and ornamentals, *I. purchasi* has also been successfully controlled by natural enemies. However, it may also suggest the possibility of a broader role for neuropterid predators in the suppression of margarodid populations.

Hemerobiid-Pseudococcid Associations. The preponderance of hemerobiid associations with coccoid insects in the family Pseudococcidae, particularly brown lacewing species in the genus *Sympherobius*, suggests that additional taxa in this family might be good targets for further study for mealybug control.

Coniopterygid-Diaspidid Associations. The strong majority of coniopterygid associations with scales in the family Diaspididae bears further study for the possible discovery of additional predators for armored scale biological control efforts. Species in both subfamilies of the Coniopterygidae (Aleuropteryginae and Coniopteryginae) have associations with the Diaspididae. As the physically smallest members of the Neuropterida, coniopterygids may be particularly suitable as predators of the typically small scales of the family Diaspididae.

Neuropterid-Kerriid-Dactylopiid Associations. The paucity of neuropterid associations with commercially cultured members of the families Kerriidae (lac insects; three associations) and Dactylopiidae (cochineal insects; one association) is surprising, given that research involving other economically important

Table 8. Distribution of neuropterid/coccoid predator/prey associations by neuropterid family and putative region of scale origin

Neuropterid family	Putative region of scale origin							Association totals
	NE	NT	PA	OR	AF	AU	UK	No. (% of all)
Chrysopidae	10 (6)	13 (8)	42 (27)	50 (32)	9 (6)	16 (10)	18 (11)	158 (60)
Hemerobiidae	5 (8)	3 (5)	27 (42)	13 (20)	1 (2)	7 (11)	9 (14)	65 (25)
Coniopterygidae	1 (3)	—	10 (29)	11 (32)	—	2 (6)	10 (29)	34 (13)
Raphidiidae	—	—	—	—	2 (40)	—	3 (60)	5 (2)
Inocelliidae	—	—	1 (100)	—	—	—	—	1 (<1)
Totals: no. (%)	16 (60)	16 (6)	80 (30)	74 (28)	12 (5)	25 (10)	40 (15)	263 (100)

AF, Afrotropical region; AU, Australasian region; NE, Nearctic region; NT, Neotropical region; OR, Oriental region; PA, Palearctic region; UK, unknown.

scale taxa has typically generated larger numbers of predator/prey associations with neuropterid taxa.

As international commerce continues to increase, the likelihood of introducing new species of pestiferous scale insects will also increase (Miller et al. 2002, 2005, Miller and Miller 2003). Given this reality, it will be important in the future to be able to distinguish which scale species may pose significant economic threats and which predator species may be useful in combating those threats. This study broadly documents the current knowledge of global neuropterid/coccoid predator/prey associations as a preliminary step for assessing the use of neuropterid insects as targeted predators to combat future scale insect introductions.

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