

## **Life cycle variation and adaptation in jumping plant lice (Insecta: Hemiptera: Psylloidea): a global synthesis**

Ian D. Hodkinson\*

*School of Biological and Earth Sciences, Liverpool John Moores University, Liverpool, UK*

*(Received 1 February 2008; final version received 20 July 2008)*

This paper integrates the scattered information on the life histories of the jumping plant lice or psyllids, examining those aspects of their biology that contribute to successful life cycle completion. Variation in life history parameters is reviewed across the world's psyllids and the relative importance of phylogeny and environment, including host-plant growth strategy, in determining life history strategies is assessed. Elements of life cycles considered include: development rate and voltinism, response to high temperature and drought, cold-hardiness and overwintering strategy, seasonal polymorphism, diapause, metabolism, host-plant selection and range, phenological and other adaptations to host plants, disease transmission and host amelioration, dispersal, reproduction and mate finding. Life history parameters are analyzed for 342 species. While a phylogenetic signal can be identified within the data, the main drivers for life history adaptation are environmental temperatures and water availability, acting directly on the psyllids or mediated through their host plants.

**Keywords:** psyllid; life-history; phylogeny; temperature; water

### **Introduction**

Jumping plant lice, or psyllids (Psylloidea), comprise a group of around 3000 species of small plant-sap-feeding insects allied to the aphids and whiteflies. They occur throughout nearly all the world's major climatic regions where suitable host plants are found. This paper attempts to integrate the wealth of scattered information on the life histories of the psyllids and to examine those aspects of their biology that contribute to successful life cycle completion. A significant proportion of this information is contained in relatively old or obscure sources, or is to be found in current literature that escapes electronic abstracting and is thus in increasing danger of remaining unrecognized. The broad variations that occur within psyllid life cycles are documented and the modifications of biology and mechanisms by which psyllids adapt to exploit a diverse range of host plants growing under varying environmental conditions are examined. An attempt is made throughout to identify common themes and patterns. Table 1 draws together, in taxonomic sequence, the basic data and reference sources that are available for the life histories of the world's Psylloidea species and this forms the foundation for the subsequent analyses.

The great majority of psyllid species are narrowly host-specific and are predominantly associated with perennial dicotyledenous angiosperms (Klimaszewski 1973; Hodkinson and White 1981; Hodkinson 1983a, 1986a, 1988a; Gegechkori and Loginova 1990; Hollis 2004). A few species develop on monocots

---

\*Email: [i.d.hodkinson@ljmu.ac.uk](mailto:i.d.hodkinson@ljmu.ac.uk)

including *Livia* spp. on *Carex* and *Juncus*, *Bactericera tremblayi* (Wagner) and *B. kratovichii* (Vondracek) on *Allium* spp. (Alliaceae), and a few species on Palmaceae. These include an undescribed species on *Bactris gasipaes* in Colombia, five Hawaiian Megatrioza on *Pritchardia*, an undescribed Australian paurocephaline species on *Livistona* and an undescribed Indian “Psylla” species on *Areca catechu* (Klimaszewski 1973; Pava et al. 1983; Uchida and Beardsley 1988; Hodkinson and Bird 2000; Mondal et al. 2003; Hollis 2004). Gymnosperms are similarly poorly exploited as host plants, with just two species of *Ehrendorferiana* Burckhardt breeding on *Austrocedrus* and *Fitzroya* (Cupressaceae) in Chile and *Trioxa colorata* Ferris and Klyver and *T. dacrydii* Tuthill exploiting *Dacrydium* (Podocarpaceae) in New Zealand (Tuthill 1952; Burckhardt 2005a). Conifers, however, as discussed later, play a highly significant role as overwintering shelter plants for adults from a wide range of psyllid species.

The psyllid life cycle typically comprises of an egg stage, five larval instars and a sexually reproducing adult stage, with males and females usually showing only moderate deviation from a 1:1 sex ratio at emergence. Parthenogenetic reproduction, in which only females are found in the population, is rare but probably occurs in some populations of *Cacopsylla rara* (Tuthill), *Glycaspis operta* (Moore), *Glycaspis atkinsoni* Moore and *Cacopsylla myrtilli* (Wagner) (Hodkinson 1983b; Moore 1983; Hodkinson and Bird 2006a). The latter species appears as populations of parthenogenetic females throughout most of its circumboreal range but males become common at higher altitudes above tree line (Hodkinson and Bird 2006a).

Within the equitable warm and wet conditions of lowland tropical evergreen rainforests psyllid life cycles tend to be continuous, with multiple generations per year. This probably typifies the environment under which psyllids originally radiated. This continuous multivoltine life cycle – appropriate to a climatically benign environment – has, however, subsequently undergone considerable modification. Psyllids have adapted to exploit a range of host plants that have themselves, over evolutionary time, diversified their physiognomy, physiology and phenology as they adapted to varying environmental conditions within widely different major climatic zones. Such evolution is driven by two overriding variables, temperature and precipitation, which vary in response to site latitude, altitude and continentality. Host plants have also undergone concomitant chemical evolution and adaptation during which their unique chemistry, in particular their complement of characteristic secondary compounds, has evolved. This unique chemistry is thought to form the basis for host selection and host fidelity in the psyllids.

In the only detailed study of psyllid plant coevolution, involving host-specific legume feeding psyllids on the Canary Islands, >60% of host associations resulted from phylogenetically conserved host switching among related legumes: strict cospeciation was only evident among more recent psyllid–host associations (Percy 2003a, 2003b; Percy et al. 2004). Thus, while precise evolutionary tracking of host plants may not always have occurred, related groups of psyllids tend usually to be typically associated with related host-plant taxa and individual psyllid species, with a few notable exceptions, display a high degree of host specificity (Hodkinson 1974, 1986b; van Klinken 2000). The exceptions are usually north temperate multivoltine pest species such as *Bactericera nigricornis*, *B. trigonica* Hodkinson and *B. cockerelli* feeding variously on a range of host-plant genera within the Solanaceae, Umbelliferae and Cruciferae (Pletsch 1947; Wallis 1955; Hodkinson 1981). Some

species that were initially thought to be polyphagous, such as the univoltine *Trioza rotundata* in Europe (on *Stellaria* (Caryophyllaceae), *Saxifraga* (Saxifragaceae) and *Cardamine* (Cruciferae), (Conci and Tamanini 1987, 1991)) have subsequently been shown to be complexes of species, each with a narrow host range (Burckhardt and Lauterer 2002).

Many psyllids form galls on their host plant. These may include simple irregular distortions of the leaf or shoot, through leaf pit galls or roll leaf galls to complex enclosed gall structures on leaves, shoots, flowers rootlets and stems. Detailed information on gall formation and the morphological adaptations for living in different types of galls is reviewed by Hodkinson (1984) and Burckhardt (2005b). This study avoids detailed description of gall formation and focuses, where appropriate, on the adaptive significance of galls within individual psyllid life cycles.

The paper initially considers the important constraints, adaptations and modifications of psyllid biology that have shaped their life cycles. It analyzes how these life cycle elements and adaptations have been assembled and combined to produce the wide range of life histories we observe among the world's psyllid fauna today. The relative significance of phylogeny and environment are assessed as predictors of psyllid life histories.

### Important elements of psyllid life histories

#### *Development rate and voltinism*

Ambient temperature is a major determinant of egg and larval development rates in non-diapausing psyllids and, as such, governs the potential number of generations per annum (voltinism). The slowest development rate recorded is for *Strophingia ericae* on *Calluna* at high elevation, which, including two periods of winter diapause, takes 2 years to complete one generation, (Hodkinson 1973b). By contrast, multivoltine tropical/subtropical species such as *Heteropsylla cubana*, *Diaphorina citri*, *Trioza erythrae* and *Trioza magnicauda*, with free-running life cycles, may complete between 8 and 16 generations per annum (Table 1). Development rates and resultant generation times may, however, differ between seasons, depending on varying ambient temperatures as in *Phytolyma fusca* on *Milicia*, *Ctenarytaina spatulata* on *Eucalyptus* and *Diaphorina citri* on *Citrus* (Ledoux 1955; Bigornia and Obana 1974; Shahid and Khan 1976; Perez Otero et al. 2005). Many temperate species are univoltine, with a relatively short development period compressed within and synchronized with the early growing season of the host plant (Table 1). Arctic species, including many *Cacopsylla*, *Psylla* and *Bactericera* species, despite their adaptations to harsher climates, almost invariably show a similar trend to univoltinism (Table 1) (Hodkinson et al. 1979; Hodkinson and Bird in press). Among multivoltine temperate species such as *Trioza urticae* on *Urtica*, various *Cacopsylla* spp. on *Pyrus* and *Agonoscena cisti* on *Pistacia* the number of generations per annum rarely exceeds six, and is usually no more than three to four (Onillon 1969; An et al. 1996; Lauterer 1998; Souliotis and Tsourgianni 2000). Some widely distributed species, such as *Trioza cinnamomi* on *Cinnamomum* are univoltine in the cooler parts of their range but become multivoltine elsewhere (Miyatake 1969; Rajapakse and Kulasekera 1982). *Strophingia ericae*, cited previously, becomes uni- rather than semivoltine at lower warmer altitudes (Hodkinson 1973b).

Table 1. Life history characteristics of the world Psylloidea. The psyllid classification follows White and Hodkinson (1985) updated to include recent changes. Where subfamilies comprise of a single tribe the subfamily name is given. Note: abbreviations: climatic zone: TrM, tropical moist; TrD, tropical dry; TrS, tropical seasonal; M, Mediterranean; TeM, temperate moist; TeD, temperate dry; B, boreal; plant functional type of Raunkiaer, based on overwintering strategy: P, *Phanerophyte* (tall trees and shrubs, overwintering buds above soil surface); C, *Chamaephyte* (low growing or prostrate dwarf shrubs, overwintering buds <25 cm above soil surface); H, *Hemicryptophyte* (overwintering bud at soil surface); G, *Geophyte* (overwintering bud below soil surface); He, *Helophyte* (marsh plants); T, *Therophyte* (overwintering as seed); Par, parasitic on other plants; d, deciduous; e, evergreen; s, semideciduous; overwintering stage: E, egg; L, larva; A, adult; overwintering site: on the host plant: T, trunk/stem; S, shoot; L, leaf; R, roots; B, buds; elsewhere: C, conifers/evergreen shrubs; LL, leaf litter; voltinism: M, multiple generations per year, number not fully determined, otherwise number of generations per annum stated; feeding site: S, shoot apex; L, expanded leaf; F, flower; St, stem; B, buds; gall type: D, general distortion of leaf and/or shoot; P, pit gall on leaf; R, roll leaf gall; Ro, root gall; Lf, leaf-fold gall; F, flower gall; El, enclosed leaf gall; Es, enclosed stem gall; Eb, enclosed bud gall; lerp formation indicated by (X).

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
<b>Psyllidae</b>												
Strophinginae	<i>Strophingia ericae</i> (Curtis)	TeM	Pe/C	L	S		1 or 0.5	S			<i>Calluna</i>	Hodkinson (1973a, 1973b), Parkinson and Whittaker (1975), Lauterer (1976), Whittaker (1985), Miles et al. (1997, 1998), Hodkinson et al. (1999), Butterfield et al. (2001)
	<i>S. cinereae</i> Hodkinson	TeM/M	Pe/C	L	S		1	S			<i>Erica</i>	Rapisarda (1990a), Hodkinson et al. (1999)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Liviinae	<i>Livia crefeldensis</i> Mink	TeM	H	A	S		1	S	D		<i>Carex</i>	Ossiannilsson (1992)
	<i>L. junci</i> (Schrank)	TeM	H	A	S		1+	S	D		<i>Juncus</i>	Verrier (1929), Heslop-Harrison (1949b), Schmidt (1966), Gegechkori (1984)
	<i>L. maculipennis</i> (Fitch)	TeM	H	A		C	1?	S	D		<i>Juncus</i>	McAtee (1915), Weiss and West (1922), Heslop-Harrison (1949b), Gegechkori (1984)
	<i>L. mediterranea</i> Loginova	M/TeD	H	A		C	1	S			<i>Juncus</i>	
Aphalarinae												
Phytolymini	<i>Phytolyma fusca</i> Alibert	TrS	Ps	ELA	S		M	S/L	El		<i>Milicia</i>	Vossler (1906), White (1966, 1967), Ledoux (1955)
	<i>P. lata</i> (Walker)	TrS	Ps	ELA	S		M	S/L	El		<i>Milicia</i>	White (1966, 1967), Cobbinah (1986), Mead (1983)
Gytropsyllini	<i>Gytropsylla ilicis</i> (Ashmead)	TrS	Pe	A	S		1	L	R		<i>Ilex</i>	
	<i>G. spegazziniana</i> (Lizer)	TeM	Pe	E	S		1	L	R		<i>Ilex</i>	Brèthes (1921), Leite and Zanol (2001)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Aphalarini	<i>Aphalara affinis</i> (Zetterstedt)	TeM	H	A	C	C	1?	L			<i>Stellaria</i>	Ossiannilsson (1992)
	<i>A. avicularis</i> Ossiannilsson	TeM	H	A	C/L	C/L	2+	L	P		<i>Polygonum</i>	Lauterer (1991), Ossiannilsson (1992)
	<i>A. borealis</i> Heslop-Harrison	TeM	H	A	C	C	1				<i>Polygonum</i>	Lauterer (1979), Conci et al. (1993)
	<i>A. calthae</i> (L.) Ossiannilsson	TeM	He	A	C	C	1	S/L/F			<i>Caltha</i>	Ossiannilsson (1992)
	<i>A. crispicola</i> Ossiannilsson	TeM	H	A	C	C	?	L	P		<i>Rumex</i>	Lauterer (1982)
	<i>A. exilis</i> (Weber and Mohr)	TeM	H	A	C/L	C/L	1	S			<i>Rumex</i>	Lauterer (1976), Gegechkori (1984), Ossiannilsson (1992)
	<i>A. freiji</i> Burekhardt and Lauterer	TeM	H	A	C	C	1-2	S			<i>Polygonum</i>	Gegechkori (1984), Lauterer (1991), Ossiannilsson (1992), Conci et al. (1993) (all as <i>A. polygona</i> ), Burekhardt and Lauterer (1997)
	<i>A. longicaudata</i> Schaefer	TeM	H	A	C/L	C/L	1	S			<i>Polygonum</i>	Lauterer (1976)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Aphalarini	<i>A. maculipennis</i> L�w	TeM	H	A		C	1	L			<i>Polygonum</i>	Gegechkori (1984), Conci et al. (1993)
	<i>A. nigrimaculosa</i> Gegechkori	TeD	H	A		?	1	?			<i>Rumex</i>	Gegechkori (1984)
	<i>A. polygona</i> Foerster	TeM	H	A		C	2	L			<i>Rumex</i>	Lauterer (1982), Gegechkori (1984), Ossiannilsson (1992) (all as <i>A. rumitcola</i> ) Burckhardt and Lauterer (1997) Conci et al. (1993)
	<i>Craspedolepta bulgarica</i> (Klimaszewski)	TeM	H	L	R?		1	S			<i>Achillea</i>	
	<i>C. campestris</i> Lauterer and Burckhardt	TeM	H	L	S		1	S			<i>Senecio</i>	Lauterer and Burckhardt (2004)
	<i>C. conspersa</i> (L�w)	TeM	H	L	R?		1	S			<i>Artemisia</i>	Conci et al. (1993)
	<i>C. crispata</i> Lauterer and Burckhardt	TeM	H	L	S		1	S			<i>Senecio</i>	Lauterer and Burckhardt (2004)
	<i>C. eas</i> (McAtee)	TeD	H	L	S		1	St			<i>Phlox</i>	Wheeler (1994)
	<i>C. flavipennis</i> (Foerster)	TeM	H	L	S		1	S			<i>Leontodon</i>	Lauterer and Burckhardt (2004)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Aphalarini	<i>C. malachitica</i> (Dahlbom)	TeM	H	L	R?		1	S			<i>Artemisia</i>	Conci et al. (1993), Hodkinson (unpublished)
	<i>C. nebulosa</i> (Zetterstedt)	TeM/B	H	L	R		1	S			<i>Chamerion</i>	Lal (1934), Sampo (1975), Lauterer (1993a), Bird and Hodkinson (1999, 2005), Hodkinson and Bird (2006b)
	<i>C. nervosa</i> (Foerster)	TeM	H	L	R		1	L			<i>Achillea</i>	Lauterer (1991), Hodkinson (unpublished)
	<i>C. omissa</i> Wagner	TeM	H	L	R		1?	S			<i>Artemisia</i>	Lauterer (1991)
	<i>C. sonchi</i> (Foerster)	TeM	H	L	S		1?	S			<i>Leontodon</i>	Lauterer and Burckhardt (2004)
	<i>C. schwarzi</i> (Ashmead)	B	H	L	R?		1	S			<i>Chamerion</i>	Hodkinson and Bird (1998, unpublished)
	<i>C. subpunctata</i> (Foerster)	TeM	H	L	R		1	R/S	Ro		<i>Chamerion</i>	Lauterer and Baudys (1968), Bird and Hodkinson (1999, 2005), Hodkinson and Bird (2006b)



Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Aphalarini	<i>C. veaziei</i> (Patch)	TeM/TeD	H	L	S		1	S			<i>Solidago</i>	Journet (1984), Hodkinson (unpublished) Conci et al. (1993)
	<i>Rhodochlanis bicolor</i> (Scott)	M	Th	EL	S		1	S			<i>Salicornia, Suaeda Salsola, Petrosimonia Suaeda</i>	Conci et al. (1993)
	<i>R. salsolae</i> (Lethierry)	M	Pe	EL	S		1	S			<i>Suaeda</i>	Conci et al. (1993)
Rhinocolimae												
Rhinocolini	<i>Agonoscena cisti</i> (Puton)	M	Pe	A		L	5-6	L			<i>Pistacia</i>	Lauterer et al. (1998), Souliotis and Tsourgianni (2000)
	<i>A. pistaceae</i> Burckhardt and Lauterer	TeD	Pe	A	T		2-5	L			<i>Pistacia</i>	Tokmakoglu (1973), Mohammed and Sheet (1989) (as <i>targionii</i> ), Souliotis and Tsourgianni (2000), Mehrnejad (2002), Mehrnejad and Copland (2005, 2006a, 2006b)
	<i>A. succincta</i> (De Geert)	M	Pe	L	L		3	L			<i>Ruta</i>	Heeger (1856), Douglas (1878), Boselli (1930), Ramirez Gomez (1960)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltnism	Feeding site	Gall	Lerp former	Host plant(s)	References
Rhinocolini	<i>A. targionii</i> Lichtenstein	M	Pe	A	S		M	S			<i>Pistacia</i>	Davatchi (1958), Conci et al. (1993)
	<i>Rhinocola aceris</i> (Foerster)	TeM	Pd	E	S		1	S			<i>Acer</i>	Löw (1880), Gegechkori (1984), Lauterer (1991), Rapisarda and Belcari (1999)
	<i>R. fusca</i> Burckhardt	M	Pd	EN	S		1	S			<i>Acer</i>	Conci et al. (1993)
Pachypsy- lloidini	<i>Acaerus calligoni</i> (Baeva)	TeD	Pe	L	S		1	S			<i>Calligonum</i>	Loginova (1970, 1976)
	<i>A. deminutus</i> (Loginova)	TeD	Pe	L	S		1	S			<i>Calligonum</i>	Loginova (1970, 1976)
	<i>A. luridus</i> (Loginova)	TeD	Pe	L	S		1	S			<i>Calligonum</i>	Loginova (1970, 1976)
	<i>A. memoratus</i> (Loginova)	TeD	Pe	L	S		1	S			<i>Calligonum</i>	Loginova (1970, 1976)
	<i>A. tumidulus</i> (Loginova)	TeD	Pe	L	S		1	S			<i>Calligonum</i>	Loginova (1970, 1976)
	<i>A. turkistanika</i> (Löw)	TeD	Pe	L	S		1	S			<i>Calligonum</i>	Loginova (1970, 1976)
	<i>Pachypsyllodes aemulus</i> Loginova	TeD	Pe	L	S		>1	S	Es		<i>Calligonum</i>	Loginova (1970)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Pachypsy- lloidini	<i>P. argutus</i>	TeD	Pe	L	S		>1	S	Es		<i>Calligonum</i>	Loginova (1970)
	Loginova											
	<i>P. errator</i>	TeD	Pe	L	S		>1	S	Es		<i>Calligonum</i>	Loginova (1970)
	Loginova											
	<i>P. patulus</i>	TeD	Pe	L	S		>1	S	Es		<i>Calligonum</i>	Loginova (1970)
Paurocephalinae	Loginova											
	<i>P. pompatus</i>	TeD	Pe	L	S		>1	S	Es		<i>Calligonum</i>	Loginova (1970)
	Loginova											
	<i>P. reverendus</i>	TeD	Pe	L	S		>1	S	Es		<i>Calligonum</i>	Loginova (1970)
	Loginova											
Paurocephalinae	<i>Camartoscena speciosa</i> (Flor)	M/TeD	Pd	A		C	2?	L	R		<i>Populus</i>	Loginova and Parfentiev (1958), Gegechkori (1984), Lauterer (1993b), Conci et al. (1993)
												Hsieh and Chen (1977)
Togepsyllinae	<i>Paurocephala psylloptera</i>	TrM	Pe	ELA	L		C	S/L	T		<i>Morus</i>	
	Crawford											
	<i>P. russellae</i> Mathur	TrM	Pe	L	L		7	L	P		<i>Kydia</i>	Mathur (1935, 1975)
	<i>Togepsylla matsumurana</i>	TeM	Pe	A		C	1	L	P		<i>Lindera</i>	Miyatake (1970)
	Kuwayama											

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Euphyllurinae												
Diclidophlebiini	<i>Diclidophlebia eastopi</i>	TrM	Ps	ELA	S		C	S			<i>Triplochiton</i>	Kudler (1968), Osisanya (1974a, 1974b)
	Vondracek											
	<i>D. harrisoni</i>	TrM	Ps	ELA	S		C	S			<i>Triplochiton</i>	Osisanya (1974a, 1974b)
	Osisanya											
	<i>D. longitarsata</i>	TrM	Pe	ELA	S		C	S			<i>Miconia</i>	Brown and Hodkinson (1988, unpublished)
	(Brown and Hodkinson)											
	<i>D. lucens</i>	TrM	Pe	ELA	S		C	S			<i>Miconia</i>	Burckhardt et al. (2005)
	(Burekhardt et al.)											
	<i>D. nebulosa</i>	TrM	Pe	ELA	L		C	L			<i>Luehea</i>	Brown and Hodkinson (1988, unpublished)
	(Brown and Hodkinson)											
	<i>D. tuxtilaensis</i>	TrM	Pe	ELA	S		C	S			<i>Conostegia</i>	Conconi (1973)
	(Conconi)											
	<i>D. xuani</i>	TrM	Pe	ELA			C	L			<i>Ricinodendron</i>	Aléné et al. (2005a, 2005b)
	Messi et al.											

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Euphyllurini	<i>Euphyllura olivina</i> (Costa)	M	Pe	A	S		3+	S			<i>Olea</i>	Silvestri (1934), Ramirez Gomez (1958), Rapisarda (1990a), Conci et al. (1993), Del Bene et al. (1997), Arambourg and Chermiti (1986), Tzanakakis (2003, 2006)
	<i>E. pakistanica</i> Loginova	TrD	Pe	A	S		1+	S			<i>Olea</i>	Thakur et al. (1989)
	<i>E. phillyreae</i> Foerster	M	Pe	A	S		1	S			<i>Olea</i> , <i>Phillyrea</i> , <i>Osmanthus</i>	Loureiro Ferreira (1946), Ramirez Gomez (1958), Prophetou and Tzanakis (1977, 1986), Stavraki (1980), Lauterer et al. (1986), Rapisarda (1991), Conci et al. (1993), Prophetou (1993, 1997), Del Bene et al. (1997), Tzanakakis (2003, 2006)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Euphyllurini	<i>E. straminea</i> Loginova	M	Pe	A	S		2-3	S			<i>Olea</i>	Mustafa (1984, 1989a, 1989b), Mustafa and Najar (1985)
	<i>Ligustrina herculeana</i> Loginova	TeM	Ps	A		C/L	1	S			<i>Ligustrum</i>	Konovalova (1976)
	<i>Neophyllura arbuti</i> (Schwarz)	TeM/M	Pe	EL	S		?	S/St		X	<i>Arbutus</i>	Ferris and Hyatt (1923)
Ctenarytainini	<i>Ctenarytaina eucalypti</i> (Ferris and Klyver)	TrS/M/ TeM	Pe	ELA	S		up to 8	S			<i>Eucalyptus</i>	Fox Wilson (1924), Azevedo and Figo (1979), Bertaux et al. (1996), Malausa and Giradet (1997), Rapisarda (1998), Hodkinson (1999), Olivares (2000), Purvis et al. (2002)
	<i>C. peregrina</i> Hodkinson	TrS/TeM	Pe	ELA	S		M	S			<i>Eucalyptus</i>	Hodkinson (2007 and unpublished)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Ctenarytainini	<i>C. spatulata</i> Taylor	TrS/M	Pe	ELA	S		M	S			<i>Eucalyptus</i>	Mansilla et al. (2004), Costanzi et al. (2003), Perez Otero et al. (2005)
	<i>C. thysanura</i> (Ferris and Klyver)	TeM	Pe	ELA	S		3	S			<i>Boronia</i>	Mensah and Madden (1992a, 1992b, 1993a, 1993b, 1994)
Diaphorinae												
Diaphorinini	<i>Diaphorina citri</i> Kuwayama	TrS	Pe	ELA	S		8-16	S			<i>Citrus</i>	Hussain and Nath (1927), Atwal (1962), Mangat (1966), Catling (1970), Atwal et al. (1970), Pande (1971), Bigornia and Obana (1974), Shahid and Khan (1976), Mead (1977), Lakra et al. (1983), Tsai and Liu (2000), Liu and Tsai (2000), Nakata (2006)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Diaphorini	<i>D. communis</i> Mathur	TrS	Pe	A	L	L	9	S			<i>Murraya</i>	Beeson (1941), Mathur (1975)
	<i>D. lycii</i> Loginova	M/TeD	Pe	ELA	S	S	5				<i>Lycium</i>	Boselli (1960) (as <i>putoni</i> ), Rapisarda (1990a)
Psyllopseini	<i>Psyllopsis discrepans</i> (Flor)	TeM	Pd	E	S	S	1-2	L	R		<i>Fraxinus</i>	Lal (1934), Gegechkori (1984)
	<i>P. distinguenda</i> Edwards	TeM	Pd	E	S	S	2	L	R		<i>Fraxinus</i>	Lauterer (1982), Conci and Tamanini (1990)
	<i>P. fraxini</i> (L.)	TeM	Pd	E	S	S	1-2	L	R		<i>Fraxinus</i>	Heslop-Harrison (1942), Loginova (1954), Nguyen (1970b), Conci and Tamanini (1990)
	<i>P. fraxinicola</i> (Foerster)	TeM	Pd	E	S	S	1-2	L			<i>Fraxinus</i>	Lal (1934), Loginova (1954), Ramirez Gomez (1956), Conci and Tamanini (1990)
	<i>P. machinosus</i> Loginova	M/TeD	Pd	E	S	S	2	L	?		<i>Fraxinus</i>	Loginova (1968), Conci and Tamanini (1990)
	<i>P. meliphila</i> (Löw)	M/TeD	Pd	E	S	S	?	L			<i>Fraxinus</i>	Rapisarda (1998)
	<i>P. narzykulovi</i> Baeva	TeD	Pd	E	S	S	2	L			<i>Fraxinus</i>	Conci and Tamanini (1990)



Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllopseini	<i>P. repens</i> Loginova	TeD	Pd	E	S		2	L	L		<i>Fraxinus</i>	Conci and Tamanini (1990)
	<i>P. securicola</i> Loginova	TeD	Pd	E	S		2	L	L		<i>Fraxinus</i>	Conci and Tamanini (1990)
Aphalaroidinae	<i>Baccharopelma baccharidis</i> (Burekhardt)	TrS	Pe	ELA	L		?	L	El		<i>Baccharis</i>	Espirito-Santo and Wilson Fernandez (1998, 2002)
Acizzinae	<i>Acizzia acaciaebaileyanae</i> (Froggatt)	TrD/M	Ps	ELA	S		M	S			<i>Acacia</i>	Conci et al. (1993), Rapisarda (1985, 1993a), Rapisarda and Belcari (1999)
	<i>A. melanocephala</i> Burckhardt and Mifsud		Ps	ELA	S		M	S			<i>Acacia</i>	Palmer and Witt (2006)
	<i>A. russellae</i> Webb and Moran	TrD	Ps	ELA	S		M	S			<i>Acacia</i>	Hoffman et al. (1975), Webb (1977), Webb and Moran (1978)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Acizzinae	<i>A. uncatoides</i> (Ferris and Klyver)	TrD/M	Ps	ELA	S		M	S			<i>Acacia</i> , <i>Albizia</i>	Heslop-Harrison (1949a) (as <i>Neopsyllia indica</i> ), Munro (1965), Koehler et al. (1966), Madubunyi (1967), Madubunyi and Koehler (1974), Leeper and Beardsley (1976), Arzone and Vidano (1985), Rapisarda (1993a), Rapisarda and Belcari (1999)
Anomoneurinae	<i>Anomoneura mori</i> Schwarz	TeD	Pd	A	S		I	S			<i>Morus</i>	Chon (1964), Kuwayama (1971), Waku and Endo (1987), Arai (1991, 1993)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Ciriacreminae	<i>Heteropsylla cubana</i> Crawford	TrD	Ps	ELA	S		M (8–10)	S			<i>Leucaena</i>	Moxon (1984), Chazeau (1987), Oka and Bahgiawati (1988), Singh (1988), Yasuda and Tsurumachi (1988), Takara et al. (1990), Rauf et al. (1990), Patil et al. (1994), Austin et al. (1996), Ogol and Spence (1997), Geiger and Gutierrez (2000) and Willson and Garcia (1992)
	<i>H. spinulosa</i> Muddiman et al.	TrS	Ps	ELA	S		<8	S			<i>Mimosa</i>	Willson and Garcia (1992)
	<i>H. texana</i> Crawford	TrS	Ps	ELA	S		C	S			<i>Prosopis</i>	Donnelly (2002)
Arytaininae	<i>Arytaina genistae</i> (Latreille)	TeM/M	Pe	A	S		2	S			<i>Cytisus</i>	Watmough (1968a, 1968b)
	<i>A. africana</i> Heslop-Harrison	M	Pe	E	S		2	S			<i>Adenocarpus</i>	Rapisarda (1988) (as <i>maculata</i> ), Rapisarda (1990a), Conci et al. (1993)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Arytaininae	<i>Arytainilla barbagalloi</i>	M	Pe	E	S		1	S			<i>Genista</i>	Rapisarda (1989c), Conci et al. (1993)
	Rapisarda											
	<i>A. cyrtisi</i> (Puton)	M	Pe	E	ST		1	S			<i>Genista Calicotome</i>	Rapisarda (1988, 1990a, 1990b), Conci et al. (1993)
	<i>A. spartiicola</i> (Šulc)	M	Pe	E	S		1	S			<i>Cytisus</i>	Conci and Tamanini (1985a), Conci et al. (1993)
	<i>A. spartiophila</i> (Foerster)	M	Pe	E	S		1	S			<i>Cytisus</i>	Heslop-Harrison (1951), Watmough (1968a, 1968b)
	<i>Cyamophila astragalicola</i>	TeD	C	A	?		1	S			<i>Astragalus</i>	Gegechkori (1984)
	Gegechkori											
	<i>C. caraganae</i> (Loginova)	TeD	H	A	?		1	S			<i>Caragana</i>	Gegechkori (1984)
	<i>C. caucasica</i> (Baeva)	TeD	H	A	?		1	S			<i>Glycyrrhiza</i>	Gegechkori (1984)
	<i>C. coluteae</i> Baeva	TeD	C	A	?		2	S			<i>Colutea</i>	Gegechkori (1984)
	<i>C. dicora</i> Loginova	TeD	C	A	S		1	S			<i>Astragalus</i>	Naem and Behdad (1988)
	<i>C. glycyrrhizae</i> (Becker)	TeD/M	H/C	A	?		2-3	S			<i>Glycyrrhiza</i>	Gegechkori (1984)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Arytaininae	<i>C. medicaginis</i> (Andrianova)	TeD/M	H	A	?		2	S			<i>Medicago</i>	Gegechkori (1984)
	<i>C. megrelica</i> (Gegechkori)	TeD	H/C	A	?		1	S			<i>Hedysarum</i>	Gegechkori (1984)
	<i>C. prohaskai</i> (Priesner)	TeM	H	A		C	1	S			<i>Anthyllis</i>	Conci and Tamanini (1986a, 1989b), Conci et al. (1993)
	<i>Livilla bimaculata</i> Hodkinson and Hollis	M	Pe	EL	S		1	S			<i>Genista</i>	Conci et al. (1993)
	<i>L. cognata</i> (L�ow)	TeM	Pe	E/L?	S		1	S			<i>Chamaecytisus</i> , <i>Lemboptropis</i>	Conci et al. (1993)
	<i>L. horvathi</i> (Scott)	M	Pe	EL	S		1	S			<i>Genista</i>	Conci et al. (1993)
	<i>L. magna</i> Hodkinson and Hollis	M	Pe	L	S		2	S			<i>Genista</i>	Rapisarda (1988, 1990b), Conci et al. (1993)
	<i>L. pyrenaica</i> (Mink)	TeM	Pe	AE	S		1	S			<i>Genista</i>	Conci et al. (1993)
	<i>L. retamae</i> (Puton)	M	Pe	E/L	S		1	S			<i>Retama</i>	Rapisarda (1991, 1992), Conci et al. (1993)
	<i>L. spectabilis</i> (Flor)	TeM/M	Pe	A/E	S		1	S			<i>Spartium</i>	Rapisarda (1988, 1992), Conci et al. (1993)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Arytaininae	<i>L. variegata</i> (L $\ddot{o}$ w)	TeM/M	Pe	E/L?	S		1	S			<i>Laburnum</i>	Conci et al. (1993)
	<i>L. vicina</i> (L $\ddot{o}$ w)	TeM/M	Pe	A	S		1	S			<i>Cytisus</i>	Conci and Tamanini (1988), Conci et al. (1993)
	<i>L. vittipennella</i> (Reuter)	TeM/M	Pe	L	S		1	S			<i>Genista</i>	Conci et al. (1993)
Psyllinae	<i>Psylla alni</i> (L.)	TeM	Pd	E	S		1	S			<i>Alnus</i>	Lal (1934), Lauterer (1976), Gegechkori (1984), Ossiannilsson (1992)
	<i>P. alpina</i> Foerster	TeM	Pd	E	S		1	S			<i>Alnus</i>	Conci et al. (1993)
	<i>P. betulae</i> (L.)	TeM	Pd	E	S		1	S			<i>Betula</i>	Gegechkori and Djibladzue (1976), Gegechkori (1984), Ossiannilsson (1992)
	<i>P. betulaenanae</i> Ossiannilsson	B	Pd	E	S		1	S			<i>Betula</i>	Ossiannilsson (1992), Hodkinson and Bird (In press)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>P. borealis</i> (Horvath)	B	Pd	E	S		1	S			<i>Alnus</i>	Hodkinson and Bird (In press)
	<i>P. cordata</i> Tamanini	M	Pd	E	S		1	S			<i>Alnus</i>	Chiara et al. (1990), Conci et al. (1993), Rapisarda and Belcari (1999)
	<i>P. floccosa</i> Patch	TeM	Pd	E	S		1	S			<i>Alnus</i>	Patch (1909)
	<i>P. fusca</i> (Zetterstedt)	TeM	Pd	E	S		1	S			<i>Alnus</i>	Lauterer (1998), Ossiannilsson (1992), Conci et al. (1993)
	<i>P. negundinis</i> Mally	TeM	Pd	E	S		1	S			<i>Acer</i>	Mally (1894)
	<i>P. trimaculata</i> Crawford	TeM	Pd	E	S		1	S			<i>Prunus</i>	Osborn (1922)
	<i>Baeopelma colorata</i> (L�w)	M	Pd	E	S		1	S			<i>Ostrya</i>	Rapisarda (1990b), Conci et al. (1993)
	<i>B. foersteri</i> (Flor)	TeM	Pd	E	S		1	S			<i>Alnus</i>	Lal (1934), Lauterer (1976), Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1993)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>Asphagidella buxi</i> (L.)	TeM/M	Pe	EL	S		1	L	D		<i>Buxus</i>	Lal (1934), Wilcke (1941), Nguyen (1965, 1968, 1969), Sampo (1975), Malenovsky (1999)
	<i>Spanioneura fonscolombei</i> (Foerster)	TeM/TeD	Pe	EA?	S		1 or M?	L			<i>Buxus</i>	Ramirez Gomez (1956), Conci et al. (1993) (literature disagrees)
	<i>S. caucasica</i> Loginova	TeD	Pe	E	S		1	?			<i>Buxus</i>	Gegechkori and Djibladzne (1976)
	<i>Cacopsylla sensu stricto</i>											
	<i>Cacopsylla mali</i> (Schmidberger)	TeM	Pd	E	S		1	S			<i>Malus</i>	Brittain (1922a, 1922b, 1923a, 1923b), Speyer (1929), Przybylski (1970), Jonsson (1983), Gegechkori (1984), Lauterer (1999)
	<i>C. peregrina</i> (Foerster)	TeM	Pd	E	S		1	S			<i>Crataegus</i>	Missonnier (1956), Sutton (1983, 1984), Gegechkori (1984)
	<i>C. sorbi</i> (L.)	TeM	Pd	E	S		1	S			<i>Sorbus</i>	Conci et al. (1993)



Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. ulmi</i> (Foerster)	TeM	Pd	E	S		1	S			<i>Ulmus</i>	Gegechkori (1984), Lauterer (1999), Ossiannilsson (1992), Conci et al. (1993)
	<b><i>Cacopsylla</i> (<i>Hepatopsylla</i>) on <i>Salix</i></b>											
	<i>C. ambigua</i> (Foerster)	TeM	Pd	E	S		1-2	S			<i>Salix</i>	Lal (1934), Lauterer (1976, 1999)
	<i>C. brunneipennis</i> (Edwards)	TeM/B	Pd	A		L	1	F/S			<i>Salix</i>	Gegechkori (1984), Hill and Hodkinson (1995), Lauterer (1999), Hill et al. (1998)
	<i>C. compar</i> (Loginova)	TeD	Pd	A		?	1	?			<i>Salix</i>	Gegechkori (1984)
	<i>C. elegantula</i> (Zetterstedt)	B	Pd	A		C	1	F/S			<i>Salix</i>	Ossiannilsson (1992), Lauterer (1999)
	<i>C. fraterna</i> (Gegechkori)	TeD	Pd	A		C	1	?			<i>Salix</i>	Gegechkori (1984)
	<i>C. groenlandica</i> (Šulc)	B	P/Cd	A		L	1	F/S			<i>Salix</i>	Hodkinson (1997), Hodkinson and Bird (In press)
	<i>C. intermedia</i> (Löv)	TeM	Pd	E	S		1	S			<i>Salix</i>	Lauterer (1999)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. iteophila</i> (Löw)	TeM	Pd	A		C	1	F/S			<i>Salix</i>	Conci and Tamanini (1989a), Conci et al. (1993)
	<i>C. macleani</i> (Hodkinson)	B	Pd	A		L	1	F/S			<i>Salix</i>	Hodkinson et al. (1979)
	<i>C. memor</i> (Loginova)	TeD	Pd	A		?	1	?			<i>Salix</i>	Gegechkori (1984)
	<i>C. moscovita</i> (Andrianova)	TeM	Cd	A		L	1	F/S			<i>Salix</i>	Gegechkori (1984), Lauterer (1993c, 1999), Ossiannilsson (1992), Hill and Hodkinson (1996)
	<i>C. nigrita</i> (Zetterstedt)	B	Pd	A		C	1	F/S			<i>Salix</i>	Gegechkori (1984), Lauterer (1999), Ossiannilsson (1992)
	<i>C. palmeni</i> (Löw)	B	Pd/Cd	A		L	1	F/S			<i>Salix</i>	Hodkinson et al. (1979), Ossiannilsson (1992), Hill and Hodkinson (1995), Hill et al. (1998)
	<i>C. parvipennis</i> (Löw)	TeM	Pd/Cd	A		L	1	F/S			<i>Salix</i>	Ossiannilsson (1992)
	<i>C. phlebophyllae</i> (Hodkinson)	B	C	A		L	1	F/S			<i>Salix</i>	Hodkinson et al. (1979)
	<i>C. propinqua</i> (Schaefer)	B	Pd	A		L	1	F/S			<i>Salix</i>	Ossiannilsson (1992), Hill and Hodkinson (1995), Hill et al. (1998)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. pulchra</i> (Zetterstedt)	TeM	Pd	A		C	1	F/S			<i>Salix</i>	Lauterer (1999), Ossiannilsson (1992), Conci et al. (1993)
	<i>C. saliceti</i> (Foerster)	TeM	Pd	A		C/L	1	F/S			<i>Salix</i>	Gegechkori (1984), Conci et al. (1993)
	<i>C. zaecevi</i> (Šulc)	B	Pd/Cd	A		L	1	F/S			<i>Salix</i>	Hodkinson et al. (1979), Ossiannilsson (1992)
	<b>Other <i>Cacopsylla</i> (<i>Hepatopsylla</i>)</b>											
	<i>C. bidens</i> (Šulc)	TeM	Pd	A	T		4-7	S			<i>Pyrus</i>	Lauterer (1979), Gegechkori (1984) (as <i>C. vasiljevi</i> )
	<i>C. corcontum</i> (Šulc)	TeM	Pd	A		C	1	S			<i>Sorbus</i>	Lauterer (1976, 1999), Ossiannilsson (1992)
	<i>C. hippophaes</i> (Foerster)	TeM/TeD	Pd	E	T		1	S			<i>Hippophae</i>	Lauterer (1982, 1993a, 1999), Gegechkori (1984), Conci et al. (1993)
	<i>C. ledi</i> (Flor)	B	Pd	A	?		1	S			<i>Ledum</i>	Ossiannilsson (1992)
	<i>C. notata</i> (Flor)	M	Pd	A	T		M	S			<i>Pyrus</i>	Conci et al. (1993)
	<i>C. myrtilli</i> (Wagner)	B	Cd	E	S		1	S			<i>Vaccinium</i>	Lauterer (1999), Ossiannilsson (1992)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. pyri</i> (L.)	TeM	Pd	A	T		2-8	S			<i>Pyrus</i>	Wille (1950), Bonnemaison and Missonnier (1955a, 1955b, 1956), Nguyen (1964, 1967a, 1967b, 1970a, 1971, 1972a, 1972b, 1973, 1975), Wojnarowska et al. (1960), Nucifora (1969), Lazarev (1979), Deronzier (1981, 1984), Deronzier and Atger (1980), Atger (1982), Gegechkori (1984), Rieux and d'Arcier (1990), Lyoussoufi et al. (1988, 1992, 1994), Stratopoulou and Kapatos (1995a, 1995b), Souliotis and Broumas (1998), Kapatos and Stratopoulou (1996, 1999), Schaub et al. (2005)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. pyricola</i> (Foerster)	TeM	Pd	A	T		3-5	S			<i>Pyrus</i>	Slingerland (1892), Ross (1919), Schaefer (1949), Siddiqui (1949), Wilde (1962, 1965), Wilde and Watson (1963), Wong and Masden (1967), Rasmy and MacPhee (1970), Burts (1970), Oldfield (1970), Radjabi and Behechti (1975), McMullen and Jong (1972, 1976, 1977), Fye (1983), Mustafa and Hodgson (1984), Savinelli and Tetrault (1984), Krysan (1990), Krysan and Higbee (1990), Horton et al. (1990a, 1990b), Horton, Higbee, et al. (1994), Horton et al. (1998), An et al. (1996)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. rhododendri</i> (Puton)	TeM	Pd	E	S		1	S			<i>Rhododendron</i>	Conci et al. (1993)
	<i>C. viburni</i> (Löw)	TeM	Pd	E	S		1	S			<i>Viburnum</i>	Gegechkori and Djibladzne (1976), Gegechkori (1984), Lauterer (1999)
	<i>C. visci</i> (Curtis)	TeM	Par on Pd	E	S		2-3	S			<i>Viscum, Loranthus</i>	Bin (1970), Lauterer (1999), Hansen and Hodkinson (2006)
	<i>C. zetterstedti</i> (Thomson)	TeM/TeD	Pd	E	T		1	S			<i>Hippophae</i>	Lauterer (1982, 1993a, 1999), Ossiannilsson (1992), Conci et al. (1993)
<i>Cacopsylla</i> ( <i>Thammopsylla</i> )	<i>C. affinis</i> (Löw)	TeM	Pd	A		C	1	S			<i>Crataegus</i>	Lauterer (1982, 1999), Sutton (1984) (as <i>subferruginea</i> )
	<i>C. alaterni</i> (Foerster)	M	Pe	ELA	S		up to 5	S			<i>Rhamnus</i>	Rapisarda (1989a, 1990a), Conci et al. (1993)
	<i>C. albipes</i> (Flor)	TeM	Pd	A		C	1	?			<i>Sorbus</i>	Gegechkori (1984), Conci et al. (1993)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. brevantennata</i> (Flor)	TeM	Pd	A		?	1-2	S			<i>Sorbus</i>	Gegechkori (1984), Lauterer (1993c, 1999), Conci et al. (1993) Gegechkori (1984)
	<i>C. cotoneasteris</i> (Loginova)	TeD	Pd	A		?	1	?				
	<i>C. crataegi</i> (Schränk)	TeM	Pd	A		C	1	S			<i>Crataegus</i>	Ramirez Gomez (1956), Nguyen (1963), Gegechkori (1984), Ossiannilsson (1992), Lauterer (1999) Rapisarda (1989a)
	<i>C. euxina</i> (Loginova)	M	Pd	ELA	S		M	S			<i>Rhamnus</i>	Gegechkori (1984)
	<i>C. fasciata</i> (Horvath)	TeD	Pd	A		C	2	S			<i>Spiraea</i>	Gegechkori (1984)
	<i>C. incerta</i> (Baeva)	TeD	Pd	A		C	1	S			<i>Rhamnus</i>	Gegechkori (1984)
	<i>C. limbata</i> (Meyer-Dur)	TeM	Pd	A		C	1	S			<i>Rhamnus</i>	Conci and Tamanini (1982, 1988), Conci et al. (1993)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. melanoneura</i> (Foerster)	TeM	Pd	A		C	1	S			<i>Crataegus</i> , <i>Malus</i>	Lal (1934), Domenichini (1967), Lazarev (1972), Sutton (1983), Gegechkori (1984), Lauterer (1999), Conci et al. (1993), Tedeschi et al. (2002) Conci et al. (1993)
	<i>C. myrthi</i> (Puton)	M	Pe	ELA	S		up to 5	S			<i>Myrthus</i>	Conci et al. (1993)
	<i>C. picta</i> (Foerster)	TeM	Pd	A		C	1	S			<i>Malus</i>	Harisanov (1966b) (as <i>costalis</i> ), Lauterer (1999)
	<i>C. pruni</i> (Scopoli)	TeM	Pd	A		C	1	S			<i>Prunus</i>	Harisanov (1966a), Gegechkori (1984), Ossiannilsson (1992), Lauterer (1999), Conci et al. (1993), Labonne and Lichou (2004)
	<i>C. pulchella</i> (L�w)	M	Pd	A		C	1	S			<i>Cercis</i>	Burckhardt (1999), Conci et al. (1993), Rapisarda and Belcari (1999)



Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Psyllinae	<i>C. pyrisuga</i> (Foerster)	TeM/M	Pd	A	C	I	S				<i>Pyrus</i>	Brocher (1926), Wojnarowska (1962), Lazarev (1975), Lauterer (1999), Ossiannilsson (1992)
	<i>C. rhamnicola</i> (Foerster)	TeM	Pd	A	C	I	S				<i>Rhamnus</i>	Gegechkori (1984), Lauterer (1999), Ossiannilsson (1992)
	<i>C. steinbergi</i> (Loginova)	TeD	Pd	A	C	I	?				<i>Ribes</i>	Gegechkori (1984)
	<i>Cacopsylla (Chamaepsylla)</i>											
	<i>C. hartigii</i> (Flor)	TW	Pd	E	S	I	S				<i>Betula</i>	Gegechkori (1984), Ossiannilsson (1992), Hodkinson (unpublished)
	<b>Other Miscellaneous 'Psylla' spp.</b>											
	<i>Psylla diospyri</i> Ashmead	TrS	Pd	E	S	2	L	R			<i>Diospyros</i>	Ashmead (1881)
	<i>Psylla isitis</i> Buckton	TrS	Pe	ELA	S	C	S				<i>Indigofera</i>	Grove and Ghosh (1914), Maxwell-Lefroy (1913), Mathur (1975)
	<i>Psylla</i> nr. <i>similae</i> Crawford	TrS	Ps	ELA	S	M up to 11	S				<i>Bauhinia</i>	Mathur (1935, 1975)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
<b>Spondyliaspidae</b>												
Euphalerinae	<i>Euphalerus hiuri</i> Miyatake	TeM	Pd	E	T		1	L	Lf		<i>Caesalpinia</i>	Miyatake (1973)
	<i>E. nidifex</i> Schwarz	TrS	Pe	ELA	L		M	L		X	<i>Piscidia</i>	Mead (1967), Russell (1971)
	<i>E. ostreoides</i> Crawford	TrS	Pe	ELA	L		M	L	El		<i>Lonchocarpus</i>	Ferreira et al. (1990)
	<i>E. vittatus</i> Crawford	TrS	Pe	E	S		5	S			<i>Cassia</i>	Beeson (1941), Mathur (1935)
Pachypsyllinae	<i>Celtisapsis japonica</i> (Miyatake)	TeM	Pd	E	S		2	S		X	<i>Celtis</i>	Miyatake (1968b, 1980, 1994)
	<i>C. usabat</i> Miyatake	TeM	Pd	E	S		1	S		X	<i>Celtis</i>	Miyatake (1980, 1994)
	<i>Pachypsylla celtidisgenma</i> Riley	TeM	Pd	L	B		1	B/L	B/El		<i>Celtis</i>	Riley (1890), Weiss (1921), Walton (1960)
	<i>P. celtidisinternis</i> Mally	TeM	Pd	A	?		1	B	B		<i>Celtis</i>	Weiss (1921), Walton (1944), Smith and Taylor (1953)
	<i>P. celtidismamma</i> (Fletcher)	TeM	Pd	A	T		1	L	El		<i>Celtis</i>	Riley (1890), Smith and Taylor (1953), Heard and Buchanan (1998)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Pachyptyllinae	<i>P. celtidisvesicula</i> Riley	TeM	Pd	A	T		1	L	EI		<i>Celtis</i>	Riley (1890), Smith and Taylor (1953)
	<i>P. venusta</i> (Osten-Sacken)	TeM	Pd	L	L		1	L	EI		<i>Celtis</i>	Riley (1890), Smith and Taylor (1953)
	<i>Tetragonocephala flava</i> Crawford	TeM	Pd	A	T		1	L		X	<i>Celtis</i>	Riemann (1958)
Spondyliaepidinae	<i>Boreioglycaspis melaleucae</i> Moore	TrS	Pe	ELA	L		C	L			<i>Melaleuca</i>	Purcell et al. (1997), Wineriter et al. (2003)
	<i>Cardiaspina albitextura</i> Taylor	TrS	Pe	ELA	L		2-3	L		X	<i>Eucalyptus</i>	Clark (1962, 1963a, 1963b), Clark and Dallwitz (1975), Morgan (1984), Collett (2001)
	<i>C. densitexta</i> Taylor	TrS	Pe	ELA	L		3	L		X	<i>Eucalyptus</i>	White (1968, 1970b, 1970c, 1973), Morgan (1984), Collett (2001)
	<i>C. fuscella</i> Taylor	TrS	Pe	ELA	L		5	L		X	<i>Eucalyptus</i>	Campbell (1992)
	<i>C. manifformis</i> Taylor	TrS	Pe	ELA	L		4	L		X	<i>Eucalyptus</i>	Campbell (1992)
	<i>Creis costatus</i> Froggatt	TrS	Pe	ELA	L		2+	L		X	<i>Eucalyptus</i>	Clark and Dallwitz (1975)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltnism	Feeding site	Gall	Lerp former	Host plant(s)	References
Spondyliaspidae	<i>Glycaspis baileyi</i> Moore	TrS	Pe	ELA	L		2+	L		X	<i>Eucalyptus</i>	Moore (1961)
	<i>G. brimlecombei</i> Moore	TrS	Pe	ELA	L		2+	L		X	<i>Eucalyptus</i>	Clark and Dallwitz (1975), Morgan (1984), Brennan, Hrusa et al. (2001), Brennan and Weinbaum (2001a, 2001b, 2001c, 2001d) Morgan (1984)
	<i>G. fuscovena</i> Moore	TrS	Pe	ELA	L		M	L		X	<i>Eucalyptus</i>	Clark and Dallwitz (1975) Solomon (1936)
Calophyidae	<i>G. prepta</i> Moore	TrS	Pe	ELA	L		M	L		X	<i>Eucalyptus</i>	
	<i>Spondyliaspis occidentalis</i> Solomon	TrS	Pe	ELA	L		M	L		X	<i>Eucalyptus</i>	
Apsyllinae	<i>Apsylla cistellata</i> (Buckton)	TrM	Pe	L	S		1	S	Es		<i>Mangifera</i>	Mathur (1935, 1946), Mani (1948), Singh M (1959), Singh S (1954, 1960), Prasad (1957), Chatterjee and Sebastian (1965), Singh and Misra (1978), Monobrullah et al. (1998)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Mastigimatiinae	<i>Mastigimas ernstii</i> (Schwarz)	TrM	Pe	ELA	L		M	L	R		<i>Cedrela</i>	Pintera (1982)
	<i>Mastigimas schwarzi</i> (Tuthill)	TrM	Pe	ELA	L		M	L	R		<i>Cedrela</i>	Pintera (1982)
Calophyinae	<i>Calophya nigra</i> Kuwayama	TeM	Pd	A		C	1	S			<i>Phellodendron</i>	Konovalova (1963), Miyatake (1992)
	<i>C. nigrilineata</i> Brown and Hodkinson	TrS	Pe	ELA	L		M	L	P		<i>Tetragastris</i>	Iglesias (1983), Brown and Hodkinson (1988, unpublished)
	<i>C. rhois</i> (L�ow)	M/TeD	Pd	E or A	S		1	L	P/R		<i>Cotinus</i>	Gegechkori (1984), Conci et al. (1996)
	<i>C. nigripennis</i> Riley	TeM	Pd	L	T		1	L			<i>Rhus</i>	Weiss and Nicolay (1918)
Phacopteroidae	<i>C. schini</i> Tuthill	TrS/M	Pe	ELA	L		M	L	P		<i>Schinus</i>	Downer et al. (1988)
	<i>C. shinji</i> Sasaki	TeM	Pe	A	S		1	L			<i>Picrasma</i>	Miyatake (1992)
	<i>C. triozomima</i> Schwarz	TeM	Pe	L	S		2	L	D		<i>Rhus</i>	Wheeler and Rawlins (1993)
	<i>Phacopteron lentiginosum</i> (Buckton)	TrS	Pe	L	L		3	L	El		<i>Garuga</i>	Mathur (1935, 1946), Raman (1987)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
<b>Homotomidae</b>												
Homotominae	<i>Homotoma ficus</i> (L.)	M	Pd	E	S		1	L			<i>Ficus</i>	Boselli (1929a), Ramirez Gomez (1956), Gegechkori (1984) (and as <i>viridis</i> ), Rapisarda (1989b) (as <i>viridis</i> ), Conci et al. (1996b), Tuncer (2002), Gencer et al. (2007) Akanbi (1980)
Triozaminae	<i>Triozamia lamborni</i> (Newstead)	TrM	Pe	ELA	S		M	S			<i>Antiaris</i>	
<b>Carsidaridae</b>												
Carsidarinae	<i>Carsidara limbata</i> (Enderlein)	TeM	Pd	E	L		1–2	L			<i>Firmiana</i>	Ding et al. (1987)
	<i>Mesohomotoma tessmannii</i> (Aulmann)	TrM	Pe	ELA	S		M	S/F			<i>Theobroma</i>	Entwistle (1972), Kaufmann (1973), Igboekwe (1983), Igboekwe and Adenuga (1983), Messi (1983a, 1983b)
	<i>Allocarsidara malayensis</i> (Crawford)	TrM	Pe	ELA	S		M	S			<i>Durio</i>	Gadug and Hussein (1987)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozidae Triozini	<i>Bactericera acutipennis</i> (Zetterstedt)	TeM	Hel	A	C	2	L	L			<i>Comarum</i>	Lauterer (1982)
	<i>B. albiventris</i> (Foerster)	TeM	Pd	A	C	2	L	L			<i>Salix</i>	Gegechkori (1984), Lauterer (1976), Ossiannilsson (1992), Conci et al. (1996)
	<i>B. atkasookensis</i> (Hodkinson)	B	Pd	A	L	1	L	L			<i>Salix</i>	Hodkinson et al. (1979)
	<i>B. brassicae</i> (Vasil'ev)	TeM	H	A	?	1	?	?			<i>Brassica</i>	Gegechkori (1984)
	<i>B. bohémica</i> (Šulc)	TeM	H	A	C	1?	L	L			<i>Geum</i>	Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1996)
	<i>B. buegica</i> (Dobreaanu and Manolache)	TeM	H	A	C	1	L	L			<i>Ranunculus</i>	Conci and Tamanini (1991), Conci et al. (1996)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Trioziini	<i>B. cockerelli</i> (Šulc)	TeD	C	ELA	L	L/C	3+	L	P/D		Solanaceae	Compere (1916), Essig (1917), Lehrman (1930), Knowlton and Janes (1931), Knowlton (1933, 1934), Knowlton and Thomas (1934), Davis (1937), Janes and Davis (1937), List (1939a, 1939b) Swenk and Tate (1940), Pletsch (1947), Wallis (1946, 1955), Liu and Trumble (2004, 2005, 2006, 2007), Liu et al. (2006)
	<i>B. crithmi</i> (Löw)	M/TeM	H	ELA	L		2+	L			<i>Crithmum</i> , <i>Ferula</i> <i>Salix</i>	Conci et al. (1996), Mifsud (1997)
	<i>B. curvatinervis</i> (Foerster)	TeM	Pd	A		C	1?	L				Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1996)
	<i>B. femoralis</i> (Foerster)	TeM	H	A		C	1–2	L			<i>Alchemilla</i>	Bin (1972), Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1996)



Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>B. harrisoni</i> (Wagner)	TeM	H	A	C	C	1	L			<i>Geum</i>	Conci et al. (1996)
	<i>B. kratochvili</i> Vondracek	TeM	G	LA	S		2-3	S			<i>Allium</i>	Lauterer (1965), Conci and Tamanini (1991), Conci et al. (1996)
	<i>B. modesta</i> (Foerster)	TeM	H	A		L	1-3?	L			<i>Sanguisorba</i> , <i>Poterium</i>	Lauterer (1991), Conci et al. (1996)
	<i>B. nigricornis</i> (Foerster)	TeM	H	A	C	C	2	L	D		<i>Solanum</i>	Heinz and Profft (1939), Ossiannilsson (1943), Biase (1983), Gegechkori (1984), Lauterer (1991), Conci et al. (1996)
	<i>B. perrissii</i> Puton	TeM	H	A		L/C	1	S			<i>Artemisia</i>	Lauterer (1982)
	<i>B. reuteri</i> (Šulc)	TeM	H	A	?	?	2?	L			<i>Potentilla</i>	Lauterer (1963), Ossiannilsson (1992)
	<i>B. salicivora</i> (Reuter)	TeM	Pd	A	C	C	?	L			<i>Salix</i>	Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1996a, 1996b)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>B. striola</i> (Flor)	TeM	Pd	A	C	C	2?	L			<i>Salix</i>	Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1996a, 1996b)
	<i>B. tremblayi</i> (Wagner)	M/TeM	G	A	C	C	7–10	S	D		<i>Allium</i>	Tremblay (1958, 1961 (as <i>nigricornis</i> ), 1965a, 1965b), Annunziata and Clemente (1980), Conci et al. (1996)
	<i>B. trigonica</i> Hodkinson	TeM	H	A	C	C	2–3	L	D		<i>Daucus</i>	Biase (1983), Lauterer (1993a), Conci et al. (1996)
	<i>Phylloplecta tripunctata</i> (Fitch)	TeM	Pd/C	A	C	C	1	S	D		<i>Rubus</i>	Sirrine (1895), Smith (1911), Felt (1906), Petersen (1923), Mead (1966a), Stuart (1991)
	<i>P. trisignata</i> (Löw)	TeM	Pd/C	A	C	C	1	L			<i>Rubus</i>	Conci and Tamanini (1984b, 1986b), Conci et al. (1996)
	<i>Egeitrioza ceardi</i> (Bergevin)	TrS	Pe	L	L	L	1	L	El		<i>Populus</i>	Mathur (1935), Beeson (1941)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Trioizini	<i>E. bifurcata</i> (Mathur)	TrS	Pe	L	S		1	S	Es		<i>Populus</i>	Mathur (1935, 1975)
	<i>E. populi</i> (Horvath)	E	Pe	L	S		1	St	Es		<i>Populus</i>	Pedata (1998)
	<i>Epirioza marginata</i> Miyatake	TeM	Pe	A	L/S	C	1	L	R		<i>Eleagnus</i>	Miyatake (1978)
	<i>E. mizuhonica</i> Kuwayama	TeM	Pe	A	L/S	C	1	L	R		<i>Eleagnus</i>	Miyatake (1978)
	<i>E. yasumatsui</i> Miyatake	TeM	Pe	A	L/S	C	1	L	R		<i>Eleagnus</i>	Miyatake (1978)
	<i>Eryngiofaga babugani</i> Loginova	TeD	H	A		?	1	?				Gegechkori (1984)
	<i>E. hungarica</i> (Klimaszewski)	TeM	H	L	S		1	S			<i>Bupleurum</i>	Lauterer (1979, 1991)
	<i>E. lautereri</i> Loginova	TeM	H	L	S		2	S			<i>Bupleurum</i>	Lauterer (1965, 1979, 1991)
	<i>Trichohermes walkeri</i> (Foerster)	TeM	Pd	E	S		1	L	R		<i>Rhamnus</i>	Sampo (1975), Lauterer (1982), Ossiannilsson (1992), McLean (1993, 1994, 1998), Conci et al. (1996)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>Leuronota trichiliae</i> Brown and Hodkinson	TrS	Pe	ELA	L		M	L	P		<i>Trichilia</i>	Brown and Hodkinson (1988, unpublished)
	<i>Neotrioza tavearesi</i> Crawford	TrS	Pe	L	L		1	L	El		<i>Psidium</i>	Butignol and Pedrosa (2003)
	<i>Triozza sensu lato</i>											
	<i>T. abdominalis</i> Flor	TeM	H	A	A	C	1?	L			<i>Achillea</i>	Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1996)
	<i>T. agrophila</i> Löw	TeM	H	A	A	C	?	L			<i>Cirsium</i>	Gegechkori and Djibladzue (1976), Gegechkori (1984), Lauterer (1991), Ossiannilsson (1992)
	<i>T. alacris</i> Flor	M	Pe	A	S		1-4	L	R		<i>Laurus</i>	Essig (1917), Weiss (1917), Lizer (1918), Weiss and Dickerson (1921), Borelli (1920), Miles (1928), Sampo (1977), Conci and Tamanini (1985b), Ramirez Gomez (1958), de Meirleire (1971), Gegechkori (1984), Conci et al. (1996)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>T. anthrisci</i> Burckhardt	TeM	H	A		C	1	L			<i>Anthriscus</i> , <i>Angelica</i>	Ossiannilsson (1992), Conci et al. (1996) (as <i>pallida</i> )
	<i>T. apicalis</i> Foerster	TeM	H	A	S		1	S	D		<i>Daucus</i>	Lundblad (1929), Bey (1931) (both as <i>viridula</i> ), Balachowsky and Mesnil (1936), Laska (1964,1974), Rygg (1977), Gegechkori (1984), Ramert and Nehlin (1989), Ossiannilsson (1992), Ellis and Hardman (1992), Conci et al. (1996), Kristoffersen and Anderbrandt (2007) Rapisarda (1993b)
	<i>T. apicalis</i> Rapisarda	M	Pd/Pe	A		C	1?	L	P?			
	<i>T. binotata</i> Conci and Tamanini	TeM	Pd	A	S		1	L			<i>Hippophae</i>	Conci and Tamanini (1984c)
	<i>T. camphorae</i> Sasaki	TeM	Pe	L	L		1	L	P		<i>Camphora</i>	Sasaki (1910), Sorin (1959a)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Trioizini	<i>T. centranthi</i> (Vallot)	TeM	H/T	A or S (ELA)	C	C	1 to M	L	D		<i>Centranthus</i> , <i>Valerianella</i>	André (1878), Ossiannilsson (1992), Conci et al. (1996)
	<i>T. cerastii</i> (L.)	TeM	C	A	C	C	1	S	D		<i>Cerastium</i>	Conci et al. (1996)
	<i>T. chenopodii</i> Reuter	TeM	H/T	A	S	2-5	L	L	D		<i>Chenopodium</i> , <i>Atriplex</i> , <i>Halimione</i>	Lauterer (1982), Baloch and Ghaffar (1984), Ossiannilsson (1992), Conci et al. (1996)
	<i>T. chrysanthemii</i> Löw	TeM	H	A	C	1	L	L	P		<i>Chrysanthemum</i>	Conci and Tamanini (1991), Conci et al. (1996)
	<i>T. cinnamomi</i> Boselli	TeM	Pe	ELA	L	1 to M	L	L	El		<i>Cinnamomum</i>	Miyatake (1969), Rajapakse and Kulasekera (1982)
	<i>T. cirsii</i> Löw	TeM	H	A	C	1	L	L			<i>Cirsium</i>	Conci and Tamanini (1990)
	<i>T. diospyri</i> (Ashmead)	TrS	Pd	E	S	2+	L	L	R		<i>Diospyros</i>	Mead (1966b)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>T. erytrae</i> (Del Guercio)	TrS	Ps	ELA	L		M up to 8	L			<i>Citrus</i>	Moran and Blowers (1967), Moran (1968a, 1968b), Catling and Annecke (1968), Catling (1969a, 1969b, 1970, 1971), van Vuuren and Moll (1984), van den Berg and Villiers (1987), Samways (1987), van den Berg and Deacon (1988), van den Berg (1990), van den Berg, Anderson, et al. (1991), van den Berg, Deacon and Steenekamp (1991), van den Berg, Deacon and Thomas (1991a, 1991b), Messi and Tamesse (1999), Tamesse and Messi (2004)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>T. eugeniae</i> Froggatt	TrS	Pe	ELA	L	M (3-5+)	L	P			<i>Syzygium</i>	Morgan (1984), Downer et al. (1991), Mead (1994), Dahlsten et al. (1995), Young (2003)
	<i>T. flavipennis</i> Foerster	TeM	H	A	C	I	L	P			<i>Aegopodium</i>	Löw (1880), Conci et al. (1996)
	<i>T. fletcheri minor</i> Crawford	TrS	Pe	ELA	L	C	L	El			<i>Terminalia</i>	Mathur (1935), Beeson (1941), Mani (1948), Das et al. (1988)
	<i>T. galii</i>	TeM	H	A	C/LL	1+?	S/L	D/R			<i>Galium</i> , <i>Aperula</i>	Boselli (1929b), Burckhardt and Lauterer (2006)
	<i>T. hirsuta</i> (Crawford)	TrS	Pe	E	S	2	L	R			<i>Terminalia</i>	Mathur (1935, 1975), Beeson (1941), Mani (1948), Dhiman and Singh (2003, 2004)
	<i>T. ilicina</i> (De Stefani Perez)	M	Pe	L	L	I	L	P			<i>Quercus</i>	Conci and Tamanini (1985c), Rapisarda and Belcari (1999), Conci et al. (1996)
	<i>T. jambolanae</i> Crawford	TrS	Pe	ELA	L	6-8	L	El			<i>Syzygium</i>	Raman (1991)



Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>T. kiefferi</i> Giard	M	Pe	A	T/S		1	L	El		<i>Rhamnus</i>	Rapisarda (1989a), Conci et al. (1996)
	<i>T. laserpitii</i> Burckhardt and Lauterer	TeM	H	A		C	1	L			<i>Laserpitium</i>	Burckhardt and Lauterer (1982), Conci et al. (1996)
	<i>T. machilicola</i> Miyatake	TeM	Pe	L	L		1	L	P		<i>Machilus</i>	Miyatake (1968a)
	<i>T. magnisetosa</i> Loginova	TeM	Pd	A	?		2	L			<i>Rhamnus</i>	Gegechkori (1984)
	<i>T. malloicola</i> (Crawford)	TrS	Pe	L	L		2-3	L	El		<i>Mallotus</i>	Mathur (1935, 1975), Beeson (1941), Mani (1948)
	<i>T. magnicauda</i> Crawford	TrM	Pe	ELA	L		9-11	L			<i>Diospyros</i>	Chang et al. (1995)
	<i>T. magnoliae</i> (Ashmead)	TrS	Pe	L	L		1	L	P		<i>Magnolia</i> , <i>Persea</i>	Mead (1963), Leege (2006)
	<i>T. munda</i> Foerster	TeM	H	A		C	1?	L	P		<i>Knautia</i> , <i>Succisa</i> , <i>Scabiosa</i>	Gegechkori (1984), Ossiannilsson (1992), Conci et al. (1996)
	<i>T. nana</i> Gegechkori	TeM	H	A	?	?	1	L			<i>Valeriana</i>	Gegechkori (1984)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>T. neglecta</i>	TeM	Pd	A	?	?	2	L			<i>Eleagnus</i>	Lauterer and Janicek (1990), Lauterer (1993a)
	Loginova											
	<i>T. obsoleta</i> Buckton	TrS	Pe	L	L		3	L	El		<i>Diospyros</i>	Vaishampayan and Bahadur (1980)
<i>T. pittiformis</i> Mathur	TrS	Pe	L	L		4	L	P		<i>Mallotus</i>	Mathur (1935, 1975)	
<i>T. proxima</i> Flor	TeM	H	A				L	P		<i>Hieracium</i>	Conci et al. (1996)	
<i>T. rapisardai</i> Conci and Tamanini	TeM	H	A				L			<i>Laserpitium</i>	Conci and Tamanini (1984d, 1988), Conci et al. (1996)	
<i>T. remota</i> Foerster	TeM	Pd	A				L	P		<i>Quercus</i>	Sorin (1959b), Gegechkori (1984), Lauterer (1991), Conci et al. (1996)	
<i>T. rhamni</i> (Schrank)	TeM	Pd	A				L	P		<i>Rhamnus</i>	Löw (1877), Gegechkori (1984), Lauterer (1991), Conci et al. (1996)	
<i>T. rotundata</i> Flor (sensu Burckhardt and Lauterer)	TeM	H	A				L/St	P		<i>Cardamine</i>	Gegechkori (1984), Conci and Tamanini (1987, 1991), Conci et al. (1996), Burekhardt and Lauterer (2002)	

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Voltinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Trioizini	<i>T. rumicis</i> Löw	TeM	H	A		C	I	F	F		<i>Rumex</i>	Sampo (1975), Gegechkori (1984), Conci et al. (1996)
	<i>T. saxifragae</i> Löw	TeM	H/G	A		C	1-2	L			<i>Saxifraga</i>	Conci and Tamanini (1986c), Lauterer (1993a), Conci et al. (1996)
	<i>T. schrankii</i> Flor	TeM	H	A		C	I	L			<i>Astrania</i>	Conci et al. (1996)
	<i>T. scottii</i> Löw	TeM	Pd/G	A		C	I	L	R		<i>Berberis</i>	Sampo (1975), Gegechkori (1984), Conci et al. (1996)
	<i>T. senecionis</i> (Scopoli)	TeM	H	A		C	I	L			<i>Senecio</i> , <i>Adenostyles</i>	Gegechkori (1984), Conci et al. (1996)
	<i>T. sonitae</i> Rapisarda	M	Pd	A		C	I	L	P		<i>Quercus</i>	Gegechkori (1984), Conci et al. (1996)
	<i>T. tabebuiae</i> Santana and Burckhardt	TrR	Pe	L	L		M	L	R		<i>Tabebuia</i>	Rapisarda (1993b), Conci et al. (1996)
	<i>T. tripteridis</i> Burckhardt et al.	TeM	H	A		C	I	L	F		<i>Valeriana</i>	De Queiroz Santana and Burckhardt (2001)
												Burckhardt et al. (1991), Conci and Tamanini (1991), Conci et al. (1996)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Triozini	<i>T. urticae</i> (L.)	TeM	H	A	C	1-4	L				<i>Urtica</i>	Lal (1934), Zhangeri (1954), Onillon (1969), Davis (1973), Sampo (1975), Gegechkori (1984), Conci et al. (1996)
	<i>T. valerianae</i> Gegechkori	TeD	H	E	S	1	L				<i>Valeriana</i>	Gegechkori and Djibladzue (1976), Gegechkori (1984), Gegechkori (1984), Ossiannilsson (1992)
	<i>T. viridula</i> (Zetterstedt)	TeM	H	A	C	?	L				<i>Cirsium</i>	Gegechkori (1984), Ossiannilsson (1992)
	<i>T. vitreoradiata</i> (Maskell)	TeM	Pe	ELA	L	2-5	L				<i>Pittosporum</i>	Carter (1949)
Pauropsyllini	<i>Pauropsylla beasoni</i> Laing	TrS	Pe	L	L	2	L		El		<i>Litsaea</i>	Mathur (1935), Beeson (1941), Mani (1948)
	<i>P. depressa</i> Crawford	TrS	Pe	L	L	1-2	L		El		<i>Ficus</i>	Mathur (1935), Beeson (1941), Mani (1948), Abbas (1967), Negi and Bisht (1989)
	<i>P. longispiculata</i> Mathur	TrS	Pe	L	L	1	L		El		<i>Buchanania</i>	Thenmozhi and Kandasamy (1992)

Table 1. (Continued.)

Higher taxon	Species	Climate zone	Plant type	Overwintering stage	Overwintering on host	Overwintering elsewhere	Volitinism	Feeding site	Gall	Lerp former	Host plant(s)	References
Pauropsyllini	<i>P. purpurescens</i> Mathur	TrS	Pe	L	L		3	L	El		<i>Ficus</i>	Mathur (1935, 1975)
	<i>P. trichaeta</i> Petty	M	Pe	ELA	L		M	L	P		<i>Ficus</i>	Awadallah and Swailem (1971)
	<i>P. udei</i> Rübtsaamen	TrS	Pe	ELA	L		M	L	El		<i>Ficus</i>	Hill (1982)

The relationship between the development rate of non-diapausing larvae and temperature is asymptotic for species such as *Agonoscena pistaciae*, *Diaphorina citri*, *Cacopsylla pyri* and *Cacopsylla pyricola* within the temperature range 5–35°C (McMullen and Jong 1977; Kapatos and Stratopoulou 1999; Liu and Tsai 2000; Nakata 2006; Mehrnejad and Copland 2006b). Development commences at the lower temperature threshold for development, rises approximately linearly to a maximum as temperature increases, but then falls back at higher temperatures, presumably in response to increasing thermal stress. By contrast, other species such as *Psyllopsiopsis fraxini*, *Mesohomotoma tessmani* and *Heteropsylla cubana* appear to show a linear response, although the maximum experimental temperatures tested (30–32°C) were lower than in the previous examples and thus probably less stressful (Nguyen 1970a; Messi 1983b; Patil et al. 1994; Geiger and Gutierrez 2000). A similar difference in response occurs between the development rate of eggs (linear) and larvae (asymptotic) of *C. pyri* over an identical temperature range, suggesting a divergence in thermal sensitivity of their respective development rate at higher temperatures (Kapatos and Stratopoulou 1999).

Temperature-specific development rates may also differ significantly among instars, although there appears to be little consistency in the trend. For example, in *Ctenarytaina thysanura* and *Trioza urticae*, at a given temperature, speed of development is highest in the early instars and progressively slows in the later instars (Onillon 1969; Mensah and Madden 1993b). By contrast, development rates in other species such as *Heteropsylla cubana*, *Mesohomotoma tessmani*, *Trioza magnicauda*, *Trioza erythrae*, *Psyllopsiopsis fraxini*, *Cacopsylla pyricola* and *Diaphorina citri*, appear highest in the intermediate instars (2–4) (Moran and Blowers 1967; Nguyen 1970b; An et al. 1996; McMullen and Jong 1977; Messi 1983b; Patil et al. 1994; Chang et al. 1995; Geiger and Gutierrez 2000; Tsai and Liu 2000; Liu and Tsai 2000).

The lower temperature threshold for larval development is comparatively low relative to ambient temperatures in tropical/subtropical species such as *Heteropsylla cubana* (9.6°C), *Trioza erythrae* (8.6–9.2°C) and *Diaphorina citri* (10.9–11.7°C) but significantly higher than in temperate species such as *Strophingia ericae* (c. 3°C), *Trioza urticae* (<6°C) and *Cacopsylla pyricola* (2–3°C) (Blowers and Moran 1968; Hodkinson et al. 1999; Kapatos and Stratopoulou 1999; Liu and Tsai 2000; Geiger and Gutierrez 2000).

Field development times from hatching egg to emerging adult in non-diapausing tropical/subtropical species including *Allocarsidara malayensis*, *Mesohomotoma tessmani*, *Diclidophlebia xuani*, *Heteropsylla cubana*, *Trioza erythrae* and *Trioza magnicauda* typically range between 9.5–23 days (Blowers and Moran 1968; Messi 1983b; Gadug and Hussein 1987; Patil et al. 1994; Chang et al. 1995; Tsai and Liu 2000). However, some less typical tropical species, such as *Euphalerus clitoriae* on *Clitoria* may take up to 34 days to complete development (Junior et al. 2005). By contrast, development times of equivalent warm to cool temperate species, including *Euphyllura olivina*, *Anomoneura mori*, *Asphagidella buxi*, *Cacopsylla melanoneura*, *C. pyricola* and *C. ambigua*, typically span around 22–44 days (Lal 1934; Loureiro Ferriera 1946; Kuwayama 1971). Development, however, can be significantly slower at temperatures just above the developmental threshold, extending to 190 days in *T. urticae* at 6°C, 56 days for *Psyllopsiopsis fraxini* at 15°C and 47 days for *Cacopsylla pyricola* at 10°C (Onillon 1969; Nguyen 1970b; McMullen and Jong 1977).

**Response to high temperature and drought**

Psyllids in tropical/subtropical and desert ecosystems are often exposed to potentially lethal high temperatures, particularly when such temperatures are coupled with low humidity to produce a high Saturation Deficit Index (SDI). High temperatures/low humidity are known to influence strongly life cycle completion in several psyllid species, where it results in reduced fecundity, increased mortality and slower rates of development at temperatures above the optimum for the species in question. It may also limit the distribution of the psyllid within the broader range of its potential host plant.

*Effect on mortality, reproduction and longevity*

The link between high temperature, SDI and mortality is particularly well-documented in *Trioza erythrae* on Rutaceae, for which models have been produced to predict population densities from these climatic variables by defining particularly lethal SDI values (Moran and Blowers 1967; Catling and Annecke 1968; Catling 1969a, 1969b; van Vuuren and Moll 1984; Samways 1987; van den Berg, Anderson et al. 1991; Tamesse and Messi 2004). Similar links between high temperature and population crashes have been observed in *Heteropsylla cubana* (>36°C) and *Glycaspis baileyi* on *Eucalyptus*, notwithstanding that larvae of the latter species secrete a protective covering or lerp (Moore 1961; Yasuda and Tsurumachi 1988; Geiger and Gutierrez 2000).

The relationship between SDI and mortality at a given standard high temperature, however, is not linear. At a low SDI *Acizzia russellae* on *Acacia* died from thermal shock associated with low evaporative cooling of host leaves. Survival rose to an optimum at a moderate SDI as evaporative cooling became more effective but then declined as the SDI increased and desiccation became significant (Hoffman et al. 1975). *Trioza hirsuta* on *Terminalia* showed similar optimal survival within the range 70–90% relative humidity (Dhiman and Singh 2003).

Among temperate species such as *Cacopsylla pyricola*, egg output per female and longevity are reduced at temperatures (<35°C) that exceed the optimum of 26.7°C. Similar suppression of egg production at high summer temperature is found in *Cacopsylla pyri* (Stratopoulou and Kapatos 1995b; Souliotis and Broumas 1998). Even in tropical species, such as *Diaphorina citri*, the optima for oviposition and development are 25–28°C, with larvae failing to develop at 33°C (Liu and Tsai 2000).

Gall-forming species, despite living within humidity-buffered galls, are not immune from a high SDI, with species such as *Euphalerus ostreoides* on *Lonchocarpus* suffering high mortality among young larvae before gall formation (Ferreira et al. 1990). However, some species in cool temperate environments such as *Craspedolepta nebulosa* and *C. subpunctata* appear physiologically capable of withstanding at least short-term exposure, as older larvae, to high temperature (40°C), provided high humidity is maintained (Bird and Hodkinson 1999).

Often the precise choice of oviposition site on a plant determines whether or not a psyllid egg survives a low SDI. Those of *Cacopsylla pyricola*, for example are less susceptible to desiccation when laid along the mid vein rather than on the leaf lamina (Horton 1990a). This is probably linked to differences in the relative availability of water within the leaf tissue for absorption through the basal pedicel of the psyllid egg, which is inserted into the plant tissue (White 1968; Conci 2000).

*Effects on distribution*

Temperature and humidity may thus affect both the absolute distribution and the relative breeding success of a psyllid species across its range. *Megatrioza* species on *Pritchardia* in the Hawaiian Islands are confined to altitudes above 425m, where temperatures are lower and humidity is higher (Uchida and Beardsley 1988). The range of *Trioza erythrae* in South Africa is limited by high temperature/SDI and even within this restricted range populations tend to increase with altitude (Catling 1969b; Green and Catling 1971; Human and Bedford 1985).

*Positive impact of drought*

Not all effects of low water availability and high temperature are negative for psyllids. Periods of atypically low winter rainfall, for example, produce water stress in *Eucalyptus fasciculosa* that is strongly correlated with subsequent population outbreaks of the psyllid *Cardiaspina densitexta* (White 1969, 1971). Stress in this instance leads to increased mobilization of soluble nitrogen within the leaves, which in turn enhances their suitability for larval development (White 1969, 1971). The effect is similar to that observed in *Cacopsylla pyricola* when its host plant is fertilized with nitrogen (Pfeiffer and Burts 1983, 1984; Daugherty et al. 2007).

*Seasonal polymorphisms**Morphological differences*

Several species of psyllid display environmentally determined seasonal polymorphisms as part of their life cycle. This has, in the past, resulted in the seasonal forms being described as distinct species. Such polymorphisms are often closely linked to diapause and have major implications for life history completion, involving key differences in performance, life history parameters and dispersal characteristics in the species concerned. These implications are discussed in detail later in the context of the factors such as day length and temperature that determine onset and breaking of diapause. Seasonal polymorphisms occur in the adults of several multivoltine species within a number of distantly related taxa, including *Agonoscena pistaceae* on *Pistacia*, *Cacopsylla pyricola*, and *C. pyri* on *Pyrus*, *Celtisaspis japonica* on *Celtis*, *Bactericera acutipennis* on *Comarum* and *Trioza chenopodii* on various *Chenopodiaceae* (Bonnemaison and Missonnier 1955a; Wong and Madsen 1967; Oldfield 1970; Nguyen 1972a, 1985; Miyatake 1980; Lauterer 1982; Mustafa and Hodgson 1984; Rieux and d'Arcier 1990; An et al. 1996; Mehrnejad 2002; Mehrnejad and Copland 2005). Polymorphism may simply involve marked seasonal differences in overall size (*Acizzia uncatoides* and *A. acaciaebaileyani* on *Acacia*) or colour (*Acizzia* spp. and *Bactericera perrissii* on *Artemisia*) among generations (Koehler et al. 1966; Lauterer 1982; Rapisarda 1993a). More frequently it additionally involves differences in such things as the relative size, shape and venation of the forewing, the presence or intensity of forewing colour patterns, the distribution and density of surface spinules in the forewing cells, minor differences in the shape of the terminalia, dark or light body colouration, and the relative length of the antenna and its component segments. In *Cacopsylla pyricola*, *C. pyri* and *A. pistaceae* the morphs usually consist of a smaller lighter coloured spring form with little or less-intense wing colour pattern and an autumn form that is larger and darker, with a distinctive



darker wing colouration or pattern. Morph determination is, however, not absolute and intermediate generations often display transitional characteristics between the extremes, or a few autumn forms may be produced even in summer generations (Mustafa and Hodgson 1984; Nguyen 1985; Rieux and d'Arcier 1990; Mehrnejad and Copland 2005). There is evidence for *C. pyri* that different features of the polymorphism, such as wing pattern or body colour are controlled to different extents by particular temperature and photoperiod exposures acting during the larval stages (Nguyen 1972a). In contrast to the aforementioned species, *Trioza chenopodii* unusually has its darker autumn form characterized by shorter and broader wings (Lauterer 1982). The darker wing-patterned autumn morph of *Pachypsylla japonica* additionally shows strong sexual dimorphism in wing pattern. The adaptive significance of this is obscure, but such sexual pattern dimorphism also occurs sporadically in both other temperate (*Livilla pogii* on *Genista*) and tropical (*Euphalerus fossiconis*, host unknown) species (Conci and Tamanini 1984a; Brown and Hodkinson 1988). Other species, such as *Crastina loginovae* on *Tamarix*, show similar strong sexual dimorphism in general body colouration (Conci and Tamanini 1983).

#### *Seasonal colour change in long-lived adults*

Long-lived adults of many temperate univoltine species undergo marked colour changes throughout the season. This may have adaptive significance through camouflage (Sutton 1983). Changes can occur gradually over several months and are often associated with a reproductive diapause. In genera such as *Cacopsylla* and *Psylla*, for example, the general body colouration changes gradually from pale colours such as green or yellow to deep red, brown and black. Adults of *Cacopsylla peregrina*, for instance, are bright green on emergence in spring, matching the colour of the leaves of their host plant, *Crataegus monogyna*, on which they are initially found. As the season progresses sexually maturing adults move from the leaves on to the darker stems as a prelude to oviposition and this is accompanied by a change in body colouration to a more cryptic brown and red (Sutton 1983).

#### *Consequences of size differences*

Temperature-induced size polymorphism resulting from varying developmental rates has strong implications for life history completion at the edge of psyllid species' ranges. For example, *Craspedolepta nebulosa* and *C. subpunctata* are univoltine species feeding on *Epilobium angustifolium*. Both are widely distributed in the temperate northern hemisphere. *C. nebulosa* shows developmental flexibility by reducing its body size and increasing its developmental temperature reaction norm as the day degrees available for larval development decrease along an altitudinal transect. *C. subpunctata* shows no such flexibility and is thus restricted to lower altitudes, thereby occupying a smaller portion of the host-plant range than *C. nebulosa* (Bird and Hodkinson 2005; Hodkinson and Bird 2006b). Atypically high temperature may also affect psyllid size. Both egg length and wing length of *Heteropsylla cubana* on *Leucaena* in Thailand decreased with rising temperature over the range 20–30°C and this was thought to be a partial explanation for a population crash during unseasonably hot weather (Geiger and Gutierrez 2000).

*Induction of seasonal morphs*

The production of different seasonal morphs is primarily controlled by day length, with temperature often playing a secondary role. For example *C. pyricola* eggs reared experimentally under short days (LD 12:12 h) produce autumn/winter-form adults; those reared under long day length (LD 16:8 or 18:6 h) produce summer forms (Mustafa and Hodgson 1984). The precise day length inducing the winter form varies, however, between studies and localities, with winter forms being produced at day lengths between 11 and 14 h in California and British Columbia respectively (Wong and Madsen 1967; Oldfield 1970; McMullen and Jong 1976). Day length acts on the early larval stages, but larvae become progressively less susceptible to a sudden switch in day length as they develop, becoming insensitive by the fourth or fifth instar (Mustafa and Hodgson 1984; An et al. 1996). The process at the relatively high experimental temperatures used appears relatively insensitive to temperature (An et al. 1996). Seasonal polymorphism in *C. pyri* and *Agonoscena pistaceae* appears to be under similar control, with short day length (LD 12:12), but coupled with low temperature (15°C) acting on instars 1–3 to produce the autumn/winter form and long day length linked to higher temperatures (25°C) resulting in spring/summer forms (Bonnemaison and Missonnier 1955a, 1955b; Nguyen 1972a; Mehmejad and Copland 2005).

*Significance of diapause*

For tropical multivoltine psyllids species living in non-seasonal environments, such as *Diaphorina citri* in the Philippines, the host plant *Citrus* spp. remains suitable for psyllid development throughout the year and life cycle progression is usually uninterrupted (Bigornia and Obana 1974). However, for species living in seasonal environments, close phenological synchrony of development with that of the host plant is a prerequisite for successful life cycle completion. Diapause provides the timing and synchronization mechanism through which psyllids are able to survive unfavourable periods, such as extended periods of cold or drought, when their host plant becomes unfavourable for development. Diapause, which involves a slowing down or cessation of development, may occur in one or more of the egg, larval and adult stages, depending on species and circumstances. It is usually controlled by environmental cues, such as photoperiod and temperature, which signal changes in the favourability of the external environment that will, when mediated through the host plant, affect psyllid development. The mechanisms that instigate and control adult diapause are well understood for a few economically important multivoltine psyllids such as *Cacopsylla pyricola* and *C. pyri* but remain unknown for the vast majority of species. Interestingly, diapausing adult *C. pyricola* are more insecticide tolerant than non-dipausing adults and this has implications for population control of economically important species (Unruh and Kryan 1994).

*Developmental diapause in eggs and larvae*

Egg diapause occurs most frequently in univoltine species associated with deciduous trees and shrubs in which eggs laid on exposed shoots and branches one year overwinter, and hatch the following year. Examples include *Psyllopsis fraxini* on *Fraxinus*, *Cacopsylla peregrina* on *Crataegus* and *Psylla alni* on *Alnus* (Lal 1934;

Nguyen 1970b; Bonnemaïson 1956). Overwintering by diapausing larvae on bare shoots is less frequent but not unknown; *Calophya triozmima*, for example, overwinters at the base of the bud of its host *Rhus* (Wheeler and Rawlins 1993). Larval winter diapause is more frequently found in free-living species that overwinter on evergreen hosts such as *Strophingia ericae* on *Calluna*, *Livilla magna* on *Genista* and *Asphagidella buxi* on *Buxus* (Nguyen 1968; Conci et al. 1993; Miles et al. 1998; Butterfield et al. 2001). Larvae cease development in the autumn and recommence in spring.

This period of suspended development may in some species also embrace a large part of the previous summer. Several leaf-gall forming species, for example, *Trioza camphorae* on *Camphora*, *Trioza cinnamomi* on *Cinnamomum*, *T. machilicola* on *Machilus*, and *T. obsoleta* on *Diospyros* hatch in spring and develop to early-stage larvae before entering diapause: development to adult only recommences the following spring (Sorin 1959a; Miyatake 1968a, 1969; Vaishampayan and Bahadur 1980). A similar extended larval diapause is found in several *Craspedolepta* species including *C. nebulosa* and *C. subpunctata* on *Epilobium*, but in these latter species there is a larval migration onto the roots or the overwintering shoots of their herbaceous perennial host (Bird and Hodkinson 1999, 2005). In these examples diapause serves to retard the production of adults and synchronize the life cycle of the psyllid with the optimum spring period for oviposition on the host. Summer larval diapause as in *Trioza saxifragae* on *Saxifraga* and species of *Acaerus* on *Calligonum* probably facilitates summer survival in particularly dry habitats (Loginova 1970, 1976; Lauterer 1993a). By contrast, diapause in *T. remota* and *T. soniae* on *Quercus* leaves and *Trioza kiefferi* on *Rhamnus*, which delay adult emergence until autumn, probably corresponds with a period when mature host leaves have become unsuitable for development. Subsequent leaf senescence in autumn then releases the soluble amino acids required for development through to overwintering adult (Conci et al. 1996).

#### *Reproductive diapause in adults*

Adult reproductive diapause, in which egg development by females is postponed, again achieves similar ends in different species. In several univoltine species of *Cacopsylla* sensu stricto, such as *C. mali* on *Malus*, *C. sorbi* on *Sorbus* and *C. peregrina* on *Crataegus*, and *Psylla* species such as *P. betulaenanae* on *Betula* and *P. borealis* on *Alnus*, adults emerge in late spring but egg development and oviposition on stems and branches is delayed until autumn (Brittain 1922a; Sutton 1983; Hodkinson and Bird in press). A possible advantage of postponed oviposition is that eggs are not exposed to predation or desiccation throughout the summer, although this must be offset against the probability of reduced female survival throughout this period.

Many psyllid species overwinter as adults, either on their host or on shelter plants (see later), and reproductive diapause ensures that eggs are not matured and laid until the following spring when the host becomes suitable for larval development. Thus, species that move onto shelter plants during winter undergo an extended diapause that delays sexual maturation of eggs until the flight to and the return from the winter host are completed. In multivoltine species such as *Cacopsylla pyricola*, *Cacopsylla pyri* and *Bactericera nigricornis* it is the autumn generation that

undergoes this reproductive diapause (Nguyen and Ledoux 1973; Nguyen 1975; Mustafa and Hodgson 1984; Krysan 1990; Krysan and Higbee 1990; Lyoussoufi et al. 1994; Horton et al. 1998). Many adult overwintering psyllids, including, for example, several *Cacopsylla* species on *Salix*, *Livia junci* on *Juncus*, *Aphalara* species on Polygonaceae, *Euphyllura phillyreae* Foerster on *Olea* and *Togepsylla matsumurana* on *Lindera* are, however, univoltine (Heslop-Harrison 1949b; Miyatake 1970; Lauterer 1976, 1979; Prophetou and Tzanakakis 1977 (as *olivina*); Hill and Hodkinson 1996; Tzanakakis 2003; Del Bene et al. 1997). They emerge in the previous spring or early summer, necessitating an even longer period of reproductive diapause to ensure host synchrony the subsequent year. Diapause may also play a role in survival during summer dry periods. *Diaphorina lycii* on Sardinia has up to five generations per annum, but breeding on the host *Lycium* is concentrated into the wetter spring and autumn and adults undergo reproductive diapause during the intervening summer (Rapisarda 1990a).

### **Control of diapause**

#### *Egg and larval diapause*

Little is known about the control of diapause in psyllid eggs and larvae. Among the few species studied, the univoltine *Asphagidella buxi* on *Buxus* overwinters in southern France as a first instar larva beneath the chorion of the egg from which it has emerged in autumn. September–December represents a period of true diapause initiated by cues unknown (Nguyen 1968). This is followed by a reactivation phase that leads up to the moult to second instar in March. Prolonged exposure to temperatures between 0–10°C for 10–30 days is necessary to break diapause but once broken the development rate during the reactivation phase is positively correlated with temperature (Nguyen 1968). Developmental inhibition, acting at different stages of larval development of *Strophingia ericae* on *Calluna* at high or low altitudes, controls whether the species undergoes a one or two year life cycle. At both altitudes eggs hatch over an extended summer period. In annual lowland populations, which overwinter predominantly in instar 3, long days (LD18:6h) retard development through instars 1–3, and development through to adult is delayed until the following spring. Instars 4 and 5 respond positively to elevated temperature and long days, from mid-winter onwards. In biennial upland populations development is slower at lower temperatures and larvae overwinter predominantly in instars 1 and 2. Development continues the following year but is inhibited by short autumn day length (LD 12:12h) in instar 5, ensuring synchrony within the population and adult emergence in spring of the following year (Miles et al. 1998; Butterfield et al. 2001).

#### *Adult diapause*

In seasonally polymorphic multivoltine species, such as *C. pyricola*, *C. pyri* and *A. pistaciae*, the factors such as photoperiod and temperature that induce the autumn morphological forms are the ones that simultaneously initiate ovarian diapause in overwintering female adults (Wong and Madsen 1967; Oldfield 1970; McMullen and Jong 1976; Mustafa and Hodgson 1984; Mehmejad and Copland 2005). Less is known about the factors inducing ovarian diapause in spring emerging adults,

although photoperiod, temperature and possibly host-plant condition are again likely to be involved. In *Euphyllura straminea* on *Olea* a mean temperature of  $>20^{\circ}\text{C}$  rather than photoperiod or host-plant quality is thought to induce summer diapause (Mustafa and Najjar 1985). For overwintering adult female psyllids ovarian diapause is usually broken at some point during the winter to be followed by a period of quiescence at low temperature when ovarian development continues to be depressed but once spring temperatures rise then egg development takes place. Adult longevity during this late-winter period may, however, decline as temperatures rise (Hill and Hodkinson 1996).

For species with an extended long ovarian diapause commencing in the previous spring, such as *Euphyllura phillyreae*, then a succession of summer, winter and spring conditions are necessary to terminate diapause (Prophetou and Tzanakakis 1986; Tzanakakis 2003). A combination of increasing day length coupled with rising temperature during winter, however, is still necessary to break ovarian diapause in the univoltine *Cacopsylla moscovita* overwintering on *Salix* (Hill and Hodkinson 1996).

For multivoltine species such as *C. pyricola* and *C. pyri* the effectiveness of long photoperiod in breaking female diapause diminishes as the winter progresses and the importance of rising temperature increases (Nguyen 1964, 1967a, 1967b, 1968, 1975; Fields and Zwick 1975; McMullen and Jong 1976; Horton et al. 1998). However, in the latter species exposure to temperatures above  $25^{\circ}\text{C}$  breaks diapause irrespective of photoperiod. The temperature required to terminate ovarian diapause generally differs both within and among species and habitats, depending on the characteristic temperatures that the species normally experience and the relative length of the winter period.

By contrast with the reproductively suppressed females, newly emerged males of the autumn diapausing form of *C. pyricola* have active sperm in the testes and seminal vesicles, but rates of insemination are depressed at short photoperiod (LD 10:14). Initially, an exposure for 10 days at long photoperiod (LD 16:8) is required to release sexual activity but the exposure time required decreases as the winter progresses (Krysan 1990; Krysan and Higbee 1990). Repeated mating and insemination of females on the overwintering host is evidenced by the presence of multiple spermatophores (mean 5.3 to 16.5 per female), with each spermatophore representing one copulation (Burts and Fischer 1967; Krysan 1990; Krysan and Higbee 1990). Psyllids collected from conifers on warm days during late winter show similar promiscuous tendencies suggesting that, for psyllids, the overwintering period is far from being a quiescent and relatively unimportant phase of the life cycle. Mating, however, does not always lead to insemination (Van den Berg, Deacon and Thomas 1991a).

Mating, before or immediately after adult diapauses, usually ensures that egg development and maturation are completed ahead of the host plant becoming suitable for oviposition, provided the temperature is sufficiently high. This applies to both summer diapausing species such as *Euphyllura straminea* and winter diapausing species such as *Cacopsylla moscovita*, *Cacopsylla pyricola* and *Euphyllura phillyreae* (Prophetou and Tzanakakis 1977, 1986; Mustafa and Najjar 1985; Lyoussoufi et al. 1994; Hill and Hodkinson 1996; Horton et al. 1998). Mature eggs of *C. moscovita* first developed in the field, for example, 6 weeks before the *Salix* catkins on which they were to be laid (Hill and Hodkinson 1996).

The larger size of overwintering morphs of multivoltine psyllid species has implications for both reproductive performance and dispersal ability of individuals. There are often major differences in the main parameters of reproduction between summer and post-diapause winter morphs of the same species, including the length of the pre-reproductive and oviposition periods, the mean number of eggs produced per female and adult longevity. For example, optimum mean fecundity in *Agonosceca pistaceae* varied between 893 and 1087 eggs per female in summer and winter morphs respectively (Mehmejad and Copland 2005). The difference is even more marked in pear psyllids with corresponding figures for *C. pyricola* of 212 (summer) and 486 (winter) in Canada and 387 and 486 in South Korea (McMullen and Jong 1977; Butt and Stuart 1986; An et al. 1996). *C. pyri* exhibits similar variation (342 and 471) (Nguyen 1970a; Kapatós and Stratopoulou 1996).

The optimum temperature for maximum fecundity may also shift between generations to match the prevailing ambient temperature. In laboratory experiments, egg output per female of *C. pyricola* was optimal at 15.6°C in the winter form but maximal at between 21.1 and 26.7°C in the summer form (McMullen and Jong 1977). The pre-reproductive period is generally shortest in summer forms, but longevity is greatest in winter forms. The net result of these variations is that egg output tends to be maximized at the start of the host-plant growing season. There may also be behavioural differences between the morphs, with summer forms showing a strong ovipositional preference for leaves but winter forms preferring dormant bud-bearing stems (Butt and Stuart 1986).

#### *Development of cold-hardiness*

Overwintering psyllids in temperate, montane and boreal habitats are frequently exposed, often over long periods, to sub-zero temperatures that may potentially damage or ultimately freeze the body tissues. Freeze tolerance is unknown among psyllids and survival depends on the ability of individual species, whether in the egg, larval or adult stage, to resist freezing by lowering the supercooling point (SCP) of their body tissues. Adult and larval stages may mitigate the effects of low air temperature to some extent by seeking out overwintering sites beneath a protective snow blanket or, in the case of adults, on evergreen trees such as conifers (Bird and Hodkinson 1999).

#### *Eggs*

Overwintering eggs, however, are often exposed on tree branches to the full rigour of winter. Those of *Cacopsylla mali* in Norway, for example, display a mean SCP that varies between -28.0°C and -38.8°C, depending on whether or not eggs have been acclimated at sub-zero (-5°C) temperature (Skanland and Sömme 1981). This allows eggs to avoid freezing, even at the very low winter temperatures recorded. The lowered SCP is achieved partly by the synthesis of cryoprotectants such as glycerol within the egg, with highest concentrations found in midwinter (Skanland and Sömme 1981).

#### *Larvae*

Recorded mean SCPs for overwintering instars include *Strophingia ericae* (range=-21.6 to -27.3°C), *S. cinereae* (-23.6 to -23.7°C), *Craspedolepta nebulosa*

( $-21.6$  to  $-23.5^{\circ}\text{C}$ ) and *C. subpunctata* ( $-21.8$  to  $-23.5^{\circ}\text{C}$ ) (Cannon 1983; Bird and Hodkinson 1999; Hodkinson et al. 1999). SCP was slightly lower in upland populations of *S. ericae* than lowland populations, although there was no difference between the mean SCP of the *S. ericae* and *S. cinereae* where they occurred together at the same site, despite the latter species being more typically Mediterranean than its congener. Similarly there was little variation in SCP of populations of *C. nebulosa* in lowland UK and Tromsø, northern Norway. SCPs of all species studied to date, despite their varying evolutionary and geographical origins, fall within a narrow range, suggesting that larvae may possess attributes that predispose them to surviving cold. Sap feeding, in particular, ensures that ice-nucleating food particles are absent from the gut. There is, however, evidence for all the aforementioned species and for *Asphagidella buxi* that the SCP should only be taken to indicate the lower limit of cold-hardiness (Nguyen 1969; Bird and Hodkinson 1999; Hodkinson et al. 1999). In both long and short time survival experiments at sub-zero temperatures, mortality accrues above the SCP as temperatures fall: mortality is related to the period of exposure as well as to temperature *per se*. Furthermore, prior acclimation at high sub-zero temperatures ( $-5$  or  $-10^{\circ}\text{C}$ ) enhances survival of fifth-instar *A. buxi* larvae at  $-15^{\circ}\text{C}$  compared with controls at  $-15^{\circ}\text{C}$ . Survival at low temperatures in species such as *A. buxi* may differ among overwintering instars, with later instars performing better. However, in the aforementioned *Strophingia* and *Craspedolepta* species, such differences were not apparent (Bird and Hodkinson 1999).

### Adults

Overwintering adults of *A. buxi* and *Cacopsylla melanoneura* are significantly less cold-hardy than eggs or larvae, as previously discussed. The SCP of *C. melanoneura*, for example, varied between  $-6.8$  and  $-14.7^{\circ}\text{C}$  when acclimated at up to 11 days at  $6^{\circ}\text{C}$  compared with  $-11.1$  to  $-15^{\circ}\text{C}$  when acclimated at  $-7^{\circ}\text{C}$  (Nguyen 1969, Jackson et al. 1990). SCP values for adults of the overwintering form of *Cacopsylla pyricola* ( $-18$  to  $-22^{\circ}\text{C}$ ), however, were comparable with larval values cited earlier and *Trioza apicalis* adults show high survival (71–87%) when exposed to  $-18^{\circ}\text{C}$  for 7 days (Rygg 1977; Horton et al. 1996; Lee et al. 1999). Freeze susceptibility, however, was markedly increased (SCP changed from  $-15^{\circ}\text{C}$  to  $-2$ – $15^{\circ}\text{C}$ ) when *C. pyricola* was placed in contact with surface moisture or bacteria such as *Pseudomonas syringi*, which act as ice-nucleating agents (Horton et al. 1996; Lee et al. 1999).

One of the mechanisms by which freeze susceptibility can be lessened is for overwintering psyllids to reduce freezable body water content before the onset of winter, as occurs in adult *C. melanoneura* and *Euphyllura straminea* (Mustafa 1989b; Jackson et al. 1990). Psyllids that become active during winter and begin fluid feeding during temporary warm spells thus run the risk of lowering their resistance to cold. Even in non-feeding adults, metabolic production of water from stored fat reserves may again potentially increase cold susceptibility (Jackson et al. 1990; Hill and Hodkinson 1996).

Psyllids have thus evolved a variety of mechanisms to prevent winter mortality in cold environments that appear largely independent of phylogeny.

**Metabolic adaptations**

In passing through their life cycles, psyllids incur the metabolic cost of respiration: energy expended in maintaining body tissue becomes unavailable for growth, development and reproduction. It is thus advantageous to minimize basal metabolism during periods of seasonal inactivity or growth cessation, especially when this is linked to diapause. Metabolic energy expenditure for individual species, measured as oxygen uptake, is influenced significantly by ambient temperature, body size and sex (Krawczyk and Migula 1979; Migula et al. 1980).

Adult male psyllids generally tend to be smaller and more active than females and, within any given species, have a higher metabolic rate per unit body weight. Similarly across adults of species representing the larger psyllid families Psyllidae and Triozidae there is a negative relationship between log respiration and log body mass, indicating that smaller species tend to respire less “efficiently” than larger species.

There are, however outliers to this general pattern: *Rhinocola aceris* and *Livia junci* (Psyllidae) have much lower rates of metabolism than might be predicted from their body size, possibly indicating their more sedentary nature (Migula et al. 1980). When measured over the range 15–25°C an array of species belonging to *Aphalara*, *Craspedolepta*, *Rhinocola*, *Livia*, *Psyllopsis*, *Arytaina*, *Psylla*, *Cacopsylla*, *Trioza*, *Trichohermes* and *Bactericera*, genera with differing degrees of phylogenetic relatedness and contrasting life history patterns, all showed significantly increasing respiration with temperature. The rate of increase, however, varied significantly among species, resulting in considerable differences in metabolism among species at a given ambient temperature.

While the species sample size is small, and the temperature range examined rather high, there is clear evidence for differences in metabolic rate among individual species with different life history adaptations (Migula et al. 1980). For example, widely distributed multivoltine species such as *Bactericera nigricornis*, *Trioza urticae* and *Cacopsylla pyri* tend to have higher metabolic rates than their univoltine congeners (Migula et al. 1980). Similarly, *Aphalara* species tend to have higher metabolism than the related *Craspedolepta*, which may reflect differences in their speed of development following overwintering as adults and larvae respectively. Among several species overwintering on conifers, such as *Aphalara exilis* and *Bactericera nigricornis*, metabolism is higher by between 20–38% during spring reproductive activity than in autumn before overwintering (Migula et al. 1980).

**Phenological synchrony with host-plant growth and host quality**

Under both temperate and tropical conditions a high degree of phenological synchrony between psyllid and host-plant growth is required for successful life cycle completion. Among temperate psyllids that overwinter as eggs, such as many *Cacopsylla*, *Psylla* and *Psyllopsis* species, egg hatch is generally timed to coincide with bud burst, although the precise mechanisms maintaining this synchrony are poorly understood (Nguyen 1970b; Lal 1934). In *Cacopsylla mali* and *C. peregrina*, for example, on *Malus* and *Crataegus* respectively, larvae hatch within a few days of the first buds breaking and move on to the newly developing plant tissues, especially the flower clusters (Przybylski 1970; Jonsson 1983; Sutton 1984; Lal 1934). This synchrony is generally strictly maintained among different sites and years



(Przybylski 1970). The importance of such close synchrony for the psyllids is emphasized in *Crataegus* by the rapid decline in the quality of their food resource, with soluble nitrogen concentrations of shoots and leaf clusters falling from around  $0.5 \text{ mg N dry weight}^{-1}$  at bud burst to less than  $0.1 \text{ mg N dry weight}^{-1}$  1 month later (Sutton 1984). Timing of egg hatch in *Homotoma ficus* on *Ficus* appears to determine subsequent larval abundance (Gençer et al. 2007). *Cacopsylla ambigua* on *Salix*, in contrast to the aforementioned species, is unusual in that eggs hatch well ahead of bud burst and the larvae remain quiescent beneath the bud scales (Lauterer 1999).

Non-gall-forming univoltine psyllids that overwinter as adults and which already contain fully developed eggs by early spring, such as *Cacopsylla moscovita* mentioned earlier, have the advantage of ovipositing directly onto newly emerging foliage as soon as it appears. This is a more precise procedure with less natural wastage than one involving small newly emerged larvae seeking out actively growing tissues. Eggs laid, however, may then take further time to hatch. *Cacopsylla affinis* and *C. melanoneura* larvae, for example, emerge 7–14 days after *C. peregrina* on the same host (Sutton 1984). This direct spring oviposition strategy is employed by a diversity of species including *Gyropsylla ilicis* on *Ilex*, several *Aphalara* species on Polygonaceae and is probably best exemplified by *Cacopsylla* species feeding on willow (*Salix*) (Mead 1983; Hodkinson et al. 1979; Hill and Hodkinson 1995; Hill et al. 1998; Hodkinson 1997).

Many of these latter species develop on female *Salix* catkins and life cycle completion within a narrow phenological window is vital. Willow catkins are of short persistence, developing early in the year before drying out and dehiscing once the seed has developed. Catkin “life” for six species of willow in northern Alaska varied between 37–43 days, depending on species. The associated psyllids, *Cacopsylla palmeni* and *C. phlebophylla* developed from egg to adult within 36–41 days, an exceedingly tight phenological schedule (Hodkinson et al. 1979). Development rates of psyllid and host are, nevertheless, independently temperature-dependent. Later studies of *C. palmeni*, *C. propinqua* and *C. brunneipennis* along altitudinal transects in Norway showed that life cycle completion was determined by the available thermal budget and its differential effect on psyllid and host development rates (Hill et al. 1995). Each psyllid had a wide distribution along the transect but failed to complete its life cycle at a characteristic upper altitudinal limit because host growth became too slow to support development or the psyllid developed too slowly to exploit the phenological window available. The upper limit for *C. palmeni* was, however, significantly higher than that for *C. brunneipennis* (Hill et al. 1995). Soluble nitrogen concentrations within catkins declined slightly with increasing altitude but the decline over time during catkin development at a given altitude was far steeper, implying a rapidly narrowing time window for psyllid development as catkins aged (Hill et al. 1998; Hodkinson et al. 2001).

MacLean (1983) extended these ideas to propose a simple temperature-driven phenological model of psyllid and host-plant development on a wider geographical scale. The latitudinal distribution of nearly all Alaskan psyllid species is more restricted than that of their host plants (MacLean and Hodkinson 1980). The model demonstrates how a psyllid’s northern limit might be set by the failure of its host plant to develop and grow sufficiently quickly to support life cycle completion within one season. The southern limit, by contrast is determined by the plant developing too quickly to permit psyllid development through to maturity. Furthermore, psyllids

may, because of phenological constraints, exploit different host plants in separate parts of their range or even exploit different tissues on the same host species. The Greenland willow psyllid *Cacopsylla groenlandica*, in the relatively benign climate of southern Greenland, reproduces on four different *Salix* species, developing on both catkins and growing shoot tips (Hodkinson 1997). Further northwards the thermal budget available for development decreases and the psyllid life cycle can be completed only on the catkins of one species, *Salix glauca*, despite other species often being present.

Among temperate species that overwinter as larvae on evergreen plants, such as *Strophingia ericae* on *Calluna* and *Asphagidella buxi* on *Buxus*, phenological synchrony is probably less important: once diapause is broken: the psyllids simply recommence development as the host plant resumes growth in the spring (Hodkinson 1973b; Nguyen 1968). Consequently, by contrast with the aforementioned *Salix*-feeding species, *S. ericae* is less dependent on precise host synchrony and occupies the full altitudinal range of *Calluna* (Hodkinson et al. 1999).

Several psyllids, particularly *Craspedolepta* species, feed and overwinter as larvae on perennial herbaceous plant species that die back each year and pass the winter with the perennating buds usually present as small rosettes at the soil surface (Hemicryptophytes) or on tubers (Geophytes). These plants, frequently associated with xerophytic conditions, often grow rapidly and flower early in the year, presenting a time-limited opportunity for psyllid exploitation. Overwintering sites of the associated psyllid larvae are usually at or below the soil surface on the rosette buds (*Craspedolepta nervosa*), on fine roots (*C. nebulosa* and *C. subpunctata*) or at the base of old woody stems (*C. eas*) (Wheeler 1994; Bird and Hodkinson 2005). In spring late instar larvae migrate to the rapidly growing shoot and quickly complete development. Larvae of the next generation then migrate back down to the overwintering site before entering a long larval diapause, usually before mid-summer. Close phenological synchrony is thus maintained and long exposure to dry summer conditions avoided.

Many species of psyllid in tropical and subtropical regions do not undergo an extended diapause and reproduction is continuous. However, many of their host species do not produce new shoots and leaves continuously but put out flushes of new growth in response to variations in ambient temperature and moisture availability. Flushing cycles may be irregular and non-synchronous within species and may vary over short geographical distances. Even within individual host plants there may be marked differences in leaf quality between sun and shade leaves. *Diclidophlebia xuani* on *Ricinodendron*, for example, tends to attain higher population density on unshaded leaf shoots whereas psyllid galls on *Persea* tend to be more numerous on shade leaves (Aléné et al. 2006; Leege 2006). This again presents synchrony problems in psyllids that need to seek out suitable tissues on flushing trees on which to complete their life cycle.

The relationship between the flushing cycle of tree and shrub species and the breeding success of their associated psyllid species has been widely documented. Good examples include *Diclidophlebia harrisoni* on *Triplochiton*, two *Phytolyma* species on *Milicia*, *Diaphorina citri* and *Trioza erytrae* on *Citrus*, *D. lycii* on *Lycium*, *Acizzia uncatoides* on *Albizzia*, several *Cardiaspina* and *Glycaspis* species on *Eucalyptus*, *Mesohomotoma tessmanni* on *Theobroma*, *Protorya* and *Diclidophlebia* species on *Argyrodendron*, and *Heteropsylla cubana* on *Leucaena* (Moore 1961; Clark

1962; White 1967; Catling 1969a; Entwistle 1972; Osisanya 1974a, 1974b; Bigornia and Obana 1974; Clark and Dallwitz 1975; Leeper and Beardsley 1976; Lakra et al. 1983; Cobbinah 1986; van den Berg and Villiers 1987; Rapisarda 1990a; Basset 1991). Similar examples have also been observed in milder temperate regions including *Ctenarytaina eucalypti* on planted *Eucalyptus* in Europe and *Trioza vitreoradiata* on *Pittosporum* in New Zealand (Carter 1949; Purvis et al. 2002).

In both the aforementioned set of species and those non-tropical multivoltine species with a winter diapause and several summer generations, such as *Cacopsylla pyricola*, successful host-plant usage depends on females correctly discerning the physiological state and condition of the host-plant tissue at the time of oviposition (White 1970a; Nguyen 1972b; Moran and Buchan 1975; Butt and Stuart 1986; Stuart et al. 1989; Horton 1990a, b; Horton and Krysan 1990, 1991; van den Berg, Anderson, et al. 1991; Mensah and Madden 1992a; Puterka et al. 1993; Luft and Paine 1997). Selection must favour young growing tissues rather than older mature leaves and shoots. For certain pest species, such as *Cacopsylla pyricola* on *Pyrus*, for which detailed information is available on the temperature dependence of diapause termination, pre-reproductive period, oviposition period and development rates, phenological models can be used to predict psyllid population growth characteristic and densities for the following summer period (Schaub et al. 2005). This can help determine when subsequent population control measures should be applied.

Many species of psyllid persist within enclosed or roll-leaf galls on the mature leaves of their host throughout much of the year. Even in these species, however, the timing of oviposition and subsequent gall initiation, to correspond with the flushing cycle of new growth, is important (Raman 1994, 2003). Gall induction usually involves the active modification of growth in young rapidly growing plant tissue and plants are thus most susceptible to galling at time of flushing (Kumar et al. 1981). Subsequent growth of plant tissue through to maturity would normally correspond with a period of declining quality for psyllid feeding that is overcome by the metabolic changes induced within the leaf as a result of psyllid feeding that allow continued development within the gall.

The close correspondence between new tissue growth and gall initiation, and increasing gall mortality on maturing leaves, has been observed in many psyllids representing several different families, including *Pachypsylla* species on *Celtis*, *Phacopteron lentiginosum* on *Garuga*, *Schedotrioza* and *Glycaspis* species on *Eucalyptus*, *Trioza simplifica* on *Terminalia*, *Trioza gigantea* on *Vaccinium*, *Calophya* spp and *Tainarys sordida* on *Schinus* and *Baccharopelma baccaridis* on *Baccaris* (Smith and Taylor 1953; Walton 1960; Kandasamy 1980; Kandasamy and Krishnan 1981; Taylor 1987; Espirito-Santo and Wilson Fernandez 1998, 2002; Saiz and Nunez 2000). In many of these species adult emergence from the gall is timed to correspond with a predictable seasonal flush of new growth and often involves a larval or adult diapause designed to maintain host-plant synchrony.

A similar situation pertains in several leaf pit-gall forming species of *Trioza* including *T. camphorae*, *T. cinnamomi*, *T. machilicola*, *T. obsoleta* and *T. ilicina* in which oviposition occurs on new flush spring growth and larval diapause corresponds with summer/winter leaf maturity (Sorin 1959a; Miyatake 1968a, 1969; Vaishampayan and Bahadur 1980; Rapisarda and Belcari 1999). Synchrony and survival may be further enhanced in species such as *Pachypsylla venusta* on *Celtis* and *Trioza tabebuiae* on *Tabebuia* in which the presence of galls prevents galled

leaves being shed during normal autumn abscission and thus remaining on the host tree (Smith and Taylor 1953; De Queiroz Santana and Burckhardt 2001). However, contrary to this trend, *Celtis laevigata* displays early abscission of leaves with *Pachypsylla* galls and this may serve as a plant defence mechanism (Stromgren and Lanciani 2001). Even in tropical tree species, including *Milicia excelsa*, staggered loss of leaves by adult trees allows small populations of associated psyllids (e.g. *Phytolyma fusca*) to survive as galls through the dry season when the majority of trees are leafless (White 1967).

### ***Development on different hosts***

The relative success of a psyllid species in completing its life history may vary significantly among different potential host species or even among different provenances within the same host species. Breeding success is determined by the initial attractiveness of a particular host, the extent to which oviposition occurs and the survival of these eggs through to adult emergence.

In large-scale host-plant trials psyllids are often found to oviposit on a much wider range of plant species than those on which they can successfully complete development (Baloch and Ghaffar 1984). *Prosopidopsylla flava*, for example, oviposited on 57 of 58 host species (Leguminosae and Rosaceae) tested but developed successfully on just four species of *Prosopis* (Leguminosae) (van Klinken 2000). Similarly, *Boreioglycaspis melaleucae* laid eggs on 27 out of 43 species of Myrtaceae but developed successfully on just two or three species of *Melaleuca* (Purcell et al. 1997; Wineriter et al. 2003).

Different species of plant within a given host range often vary in their susceptibility to the associated psyllid species, ranging across a spectrum from highly susceptible to near resistant. Examples include *Glycaspis brimblecombei* on *Eucalyptus* spp, *Ctenarytaina thysanura* on *Boronia* spp *Cacopsylla pyricola* on *Pyrus* and *Heteropsylla cubana* on *Leucaena* spp (Williams et al. 1963; Westigard et al. 1970; Mensah and Madden 1991; Brennan, Hrusa, et al. 2001; Mullen and Shelton 2003; Pasqualini et al. 2006; Center et al. 2007).

Similar variation in susceptibility also occurs across provenances, cultivars and varieties within single species of host plant, as in *Phytolyma lata* on *Milicia excelsa*, *Acizzia melanocephala* on *Acacia nilotica*, *Cacopsylla pyricola* and *C. pyri* on *Pyrus communis*, *Heteropsylla cubana* on *Leucaena leucocephala* and *Bactericera cockerelli* on *Lycopersicon* (Harris 1973; Chang and Philogene 1976; Butt et al. 1989; Cobbinah and Wagner 1995; Berrada et al. 1995; Baldassari et al. 1996; Puterka 1997; Mullen and Shelton 2003; Finlay-Doney and Walter 2005; Liu and Trumble 2006; Pasqualini et al. 2006; Palmer and Witt 2006). Such variation forms the basis for selective breeding for host-plant resistance against pest psyllid species or identifying varieties of invasive weed species susceptible to biological control (e.g. Nguyen and Messi 1973; Lahiri and Biswas 1980; Palmer and Witt 2006; Center et al. 2006).

Sometimes the within-species variation in plant susceptibility may be as great or greater than the between-species variation. *Asphagidella buxi*, for instance, breeds naturally on *Buxus sempervirens* var *arborescens* but not on var *rotundifolia*, yet it breeds successfully on *B. macrophylla* (Nguyen 1965). Comparable apparent anomalies are found in the host range of *Heteropsylla cubana* (Mullen and Shelton 2003). Differences in susceptibility may even occur among plants of the same

provenance. The most striking example occurs in species of Myrtaceae that display heteroblasty, strong morphological differentiation between juvenile and mature foliage related to tree age (Brennan, Weinbaum, et al. 2001). *Ctenarytaina eucalypti*, for example, oviposits and develops on juvenile shoots of *Eucalyptus globulus* whereas *C. spatulata* develops primarily on the mature foliage (Brennan and Weinbaum 2001a, 2001b, 2001c).

Variation in psyllid development success among host species and cultivars can usually be explained by differences in the initial attractiveness of the foliage, differential oviposition rates, larval survival rates and larval development period. *Diaphorina citri*, when tested using four host *Citrus* species, developed most successfully on *C. paradisi* as a result of higher fecundity, faster development time in the final instar and higher larval survival (Tsai and Liu 2000; Nava et al. 2007). *Heteropsylla cubana* developed more successfully on *Leucaena leucocephala* than on *L. collinsii* in which slower colonization resulted in 46–63% fewer eggs being laid, a 67% reduction in larval survival and the production of smaller, probably less fecund adults (Lapis and Borden 1993a, 1993b). The host preference hierarchy in *Bactericera cockerelli* on *Lycopersicon* is similarly based on rates of oviposition, development and survival, although these parameters may differ between native and invasive populations of the psyllid (Liu and Trumble 2004, 2005, 2006, 2007). There are, however, apparently anomalous examples in which a host plant that is most attractive for oviposition is not the most suitable for larval development. *Trioza erythrae*, for example, oviposits preferentially on *Citrus limon* but the development period is shorter and the adult size attained is greater on indigenous Rutaceae such as *Vepris* and *Clausena* (Moran 1968a, 1968b).

The precise mechanisms that determine the preference hierarchy of host plants appear to vary among psyllid species. In *Cacopsylla pyricola*, when offered three host plant species in the laboratory, host acceptance for oviposition appeared determined by interactions among plant species, female egg load and the time for which the psyllid was deprived of a suitable host (Horton and Krysan 1991). Cues received during probing and settling released oviposition but egg laying ceased earlier on lower hierarchy species, suggesting that further cues received during oviposition were also involved in prolonging egg laying.

Other factors implicated in establishing preferences include host species phenology (*Euphyllura phillyrae*), amount of glaucous wax on the leaf surface (*Glycaspis brimblecombei*), physical hardness of the terminal shoot (*Ctenarytaina thysanura*), leaf colour (*Mesohomotoma tessmanni* and *G. brimblecombei*), the presence of attractive chemicals such as caryophyllene (*Heteropsylla cubana*) and low concentrations of repellent chemicals such as phenolics (*Cacopsylla pyricola*), terpenoids (*Boreioglycaspis melaleucae*) or glucosinolates (undescribed "*Aphalara*" sp.) (Moran and Brown 1973; Louda and Rodman 1983; Messi 1983a; Ullman and McLean 1988a; Mensah and Madden 1991; Luft and Paine 1998; Luft et al. 2001; Brennan and Weinbaum 2001a, 2001c, 2001d; Finlay-Doney and Walter 2005; Wheeler and Ordnung 2005; Prophetou 1997). In *Bactericera cockerelli* on *Lycopersicon* jumping and leaf avoidance behaviour was greatest on the most resistant cultivars, suggesting active repellence and not just an antixenosis response (Liu and Trumble 2004). A single gene (Mi-1.2) from wild tomato, *Solanum peruvianum*, confers resistance to *B. cockerelli* in some commercial tomato varieties (Casteel et al. 2007).

***Host-plant amelioration, disease transmission and endosymbionts***

Host plants, particularly when leaves are mature, provide a low quality source of soluble nutrients, especially available nitrogen in the form of amino acids, for sap-feeding psyllids. This frequently results, as noted earlier, in lower rates of reproduction, slower development and reduced longevity on mature versus young or senescing foliage (Nguyen 1972b). Psyllids, however, often display mechanisms through which they enhance, ameliorate or partly circumvent the condition of their mature host plant for larval growth and development (White 1970b).

Feeding involves the injection of saliva and its associated enzymes, such as amylase, into the host, most frequently into the phloem and its associated tissues or into leaf mesophyll (Pussard 1939; Williams and Benson 1966). This may or may not result in wider salivary translocation within the plant. Species of *Cardiaspina*, *Glycaspis*, *Creiis* and *Lasiopsylla* on *Eucalyptus blakeleyi* and *E. melliodora* induce localized symptoms of varying severity in phloem tissues that resemble premature senescence (Woodburn and Lewis 1973). In mesophyll-feeding species such as *Cardiaspina retator* on *Eucalyptus camaldulensis* feeding similarly produces cell degeneration that resembles senescence and involves the mobilization of lipids, amino acids and soluble proteins (Crawford and Wilkens 1996).

Some psyllids, including known pest species such as *Trioza apicalis* (on carrot) and *Bactericera cockerelli* (on potato and tomato), induce a wider systemic phytotoxaemia within their host, resulting in severe growth distortion, cellular necrosis and yellowing of leaves (Richards and Blood 1933; Eyer and Crawford 1933; Eyer 1937; Sanford 1952; Laska 1964; Markkula and Laurema 1971), which again resemble senescence, with the associated mobilization of soluble nitrogen and increasing the availability of nutrients to the psyllid (Laurema 1989). This may, as in *T. apicalis*, be accompanied by an increase in leaf monoterpenes concentrations and result in reduced root growth (Nissinen et al. 2005, 2007). It may also be associated with the transmission of plant diseases, particularly mycoplasmas (see next section). Gall formation, which is largely outside the scope of this review, similarly brings about improvements in host tissue quality for feeding psyllid larvae through the creation of metabolic sinks within the plant tissue (e.g. Raman 1987; Rajadurai et al. 1990; Mani and Raman 1994; Yang et al. 2006).

Enhanced amelioration may occur when psyllids feed in groups rather than singly. *Cacopsylla pyri* on *Pyrus communis* and *Cardiaspina densitexta* on *Eucalyptus fasciculosa*, for example, showed higher reproduction, greater longevity or enhanced survival with increasing feeding group density up to an optimum (White 1970b; Nguyen 1971). Galls of *Pachyopsylla celtidismamma* on *Celtis* similarly grew larger when more than one gall was present per leaf (Heard and Buchanan 1998). However, feeding by some species at high densities, such as *Boreioglycaspis melaleucae* on *Melaleuca* may promote increased leaf abscission and a decline in host quality (Morath et al. 2006). Similarly, feeding-induced changes in the concentrations of leaf nutrients, chlorophyll, minerals and phenolics may lead to an ultimate reduction in food quality for *Cacopsylla* species on *Pyrus* (Scutareanu and Loxdale 2006).

***Significance of disease transmission***

Several psyllids are known vectors of plant diseases and as such are regarded as noxious pests. However, psyllids often show close association with these pathogens.

When viewed from the psyllids' perspective, the association may prove highly beneficial by bringing about pathogen-induced changes in the host plant that makes it more acceptable or more nutritious for psyllid development (Weintraub and Beanland 2006). Pathogens may, for example, induce physiological changes resembling the premature senescence noted previously or produce reduced levels of defensive chemicals. However, our knowledge of these psyllid–pathogen relationships is confined to just a few crop plants but similar pathogens occur widely in wild hosts where the insect–vector relationships remain to be established (Weintraub and Beanland 2006).

The main plant diseases associated with and transmitted by psyllids (Table 2) are viruses, and bacteria within three main groups, the liberibacters, the phytoplasmas (previously known as mycoplasma-type organisms) and fireblight. Several of the causative agents are taxonomically poorly defined, being identified solely from their RNA, and are included in the *Candidatus* category of the bacterial classification. The disease organisms are initially ingested during psyllid feeding and are then later re-injected back into other plants with the psyllid saliva. Phytoplasmas and liberibacters in particular are restricted to the phloem sieve tubes and circulate with the plant sap, making them ideal candidates for transmission by psyllids. Within the insect they cross the gut wall, multiply in the haemolymph and migrate into the salivary glands ready for onward transmission in the saliva (Hibino et al. 1971; Chen et al. 1973; Cousin and Boudon-Padieu 2002; Hung et al. 2004; Weintraub and Beanland 2006).

Both larvae and adults appear capable of transmitting phytoplasmas (Carraro, Loi, et al. 1998; Tedeschi and Alma 2004). Some evidence exists for transovariole transfer of these bacteria between female psyllids and their offspring in psyllids such as for *Phytoplasma prunorum* in *Cacopsylla pruni* (Tedeschi et al. 2006). However, *Liberibacter asiaticum* in *Diaphorina citri* and *Phytoplasma mali* in *Cacopsylla melanoneura*, by contrast, do not appear to be vertically transmitted between generations (Hung et al. 2004; Tedeschi et al. 2006). Interestingly, infection of potato by a virus provides cross-protection against psyllid yellows phytoplasma transmitted by *Bactericera cockerelli* (Staples 1968).

Psyllids may also benefit from a general weakening of the plant caused by sooty moulds growing on the larval excreta or honeydew deposited on the leaf or shoot surface. Examples include *Cacopsylla pyricola* on *Pyrus* and *Ctenarytaina thysanura* on *Boronia* (Savinelli and Tetrault 1984; Mensah and Madden 1992b).

### *Significance of endosymbionts*

Endosymbiotic bacteria also play a more direct role in the nutrition of psyllids, which in common with aphids, whiteflies and pseudococcids, support such bacteria within, or associated with, specialized cells (bacteriocytes) that aggregate to form a bacteriome within the insect's body cavity (Tarsia in Curia 1934; Chang and Musgrave 1969; Waku and Endo 1987; Fukatsu and Nikoh 1998; Thao et al. 2000a). Phloem sap, on which many psyllids feed, is rich in sugars but poor in amino acids and it is thought that the endosymbionts synthesize essential amino acids and vitamins such as riboflavin that then become available to the psyllid (Thao et al. 2000a; Thao et al. 2001).

Table 2. List of plant diseases transmitted by psyllid vectors.

Organism	Disease	Psyllid vector	Reference
<b>Bacteria</b>			
<i>Candidatus</i> status			
Liberibacter asiaticus (in Asia and Florida)	Citrus Huanglongbing (HLB)=Greening Disease	<i>Diaphorina citri</i>	Halbert and Manjunath (2004), Davis et al. (2005), Das et al. (2007)
Liberibacter africanus (in Africa)	Citrus Huanglongbing (HLB)=Greening Disease	<i>Trioza erytreae</i>	Van den Berg et al. (1987), Anon. (1988)
Liberibacter americanus (in S. America)	Citrus Huanglongbing (HLB)=Greening Disease	<i>Diaphorina citri</i>	Teixeira et al. (2005)
Phytoplasma	Peach Yellow Leaf Roll (PYLR)	<i>Cacopsylla pyricola</i>	Purcell and Suslow (1984), Blomquist and Kirkpatrick (2002)
Phytoplasma prunorum	European Stone Fruit Yellows (ESFY)=Apricot Chlorotic Leafroll	<i>Cacopsylla pruni</i>	Carraro, Osler, et al. (1998), Jarausch et al. (2001), Carraro et al. (2004), Labonne and Lichou (2004), Delic et al. (2005)
Phytoplasma mali	Apple Proliferation (AP)	<i>Cacopsylla picta</i>	Frisinghelli et al. (2000), Jarausch et al. (2003), Tedeschi et al. (2002), Tedeschi and Alma (2004)
Phytoplasma pyri (in Europe and N.America)	Pear Decline (PD)	<i>C. melanoneura</i> <i>Cacopsylla pyricola</i> <i>C. pyri</i>	Jensen et al. (1964), Ullman and MacLean (1988b), Davies et al. (1992), Giunchedi et al. (1994), Carraro et al. (1998), Ben Khalifa et al. (2007)
Phytoplasma (in Taiwan)	Pear Decline (PDTW)	<i>Cacopsylla qianli</i> <i>C. chinensis</i>	Liu et al. (2007)
Phytoplasma	Carrot Stolbur	<i>Bactericera trigonica</i>	Font et al. (1999), Weintraub and Beanland (2006)
<b>'Rickettsia type organism'</b>			
<b>Family</b>			
<b>Enterobacteriaceae</b>			
<i>Erwinia amylovora</i>	Wissadula Proliferation (WP)	<i>Paracarsidara dugesii</i> (Löw)	Dabek (1983) (as <i>concolor</i> )
<b>Virus</b>			
(SB26/29)	Fireblight of orchard trees	<i>Cacopsylla pyricola</i> Psyllids generally	Wilde et al. (1971), Hildebrand et al. (2000)
<b>Undetermined</b>			
	Potato Rugose Stunting Virus	<i>Russelliana solanicola</i>	Tenorio et al. (2003)
	Zebra chip disease	<i>Bactericera cockerelli</i>	Munyaneza et al. (2007)



The psyllid endosymbionts fall into two main groups, primary (P) and secondary (S). The P endosymbionts, found within the bacteriocytes, are genetically similar throughout the psyllids, suggesting that they have colonized the psyllids just once, and then co-evolved with their hosts (Thao et al. 2000b). They are defined as a single taxon *Candidatus Carsonella ruddii* (Thao et al. 2001; Spaulding and von Dohlen 2001). The S endosymbionts, by contrast, are present in cells associated with the bacteriocytes and appear to be multiply derived, consisting of several distinct groups within the Eubacteriaceae (Spaulding and von Dohlen 1998; Thao et al. 2001; Fukatsu and Nikoh 1998). Their function in psyllid nutrition is less clear than for the P endosymbionts (Thao et al. 2001). Secondary endosymbiont infection levels may vary greatly among populations, as in *Glycaspis brimblecombei*, where infection appears more associated with levels of parasitism than with nutrition (Hansen et al. 2007).

### **Dispersal**

Effective dispersal is a key element in the life history of psyllids irrespective of the habitat within which they are found. In insects that are capable of flying only limited distances under their own power, it serves several important purposes. In particular, it enables a species to track the changing spatial distribution of its host plant and/or the temporal availability of the food resource that it relies on for breeding success. It allows psyllids to move between different host-plant species and to exploit non-host-plant species as overwintering sites and it permits species to escape the effects of strong intraspecific competition and natural enemies. Among economically important species, such as *Trioza erytrae*, it expedites rapid colonization of cultivated *Citrus* hosts (metapopulation sinks) by psyllids originating on indigenous host plants within the surrounding area (metapopulation sources) (van den Berg, Deacon and Steenekamp 1991).

### **Dispersal distance**

There is strong evidence to suggest that, as a group, the psyllids are highly effective dispersers over both short and long distances, although in almost all cases dispersal is wind assisted. Dispersing psyllids belonging to the genera *Cardiaspina*, *Ctenarytaina*, *Eucalyptolyma*, *Psylla* sensu lato and *Bactericera* have been taken in drogue nets towed behind light aircraft in Australia, the Galapagos Islands and the USA or in kite mounted nets in the Canary Islands (Glick 1939; White 1970a, 1973; Ashmole and Ashmole 1988; Peck 1994). Psyllids form a major component of the insect flotsom found on the surface of the sea at sites around the UK coastline and off the west coast of the USA (Cheng and Birch 1978; Hardy and Cheng 1986). Species belonging to several genera including *Aphalara*, *Craspedolepta*, *Livia*, *Cacopsylla*, *Euphalerus* sensu lato, *Acizzia*, *Bactericera* and *Trioza* are a common component of aerial deposition on high altitude snowfields in California and Tenerife (Papp and Johnson 1979) or early successional volcanic areas in the Azores (Ashmole et al. 1996). Thirty-seven species have been recorded as vagrants in yellow water traps in northern Italy and several, including *Cacopsylla melanoneura*, *C. affinis*, *Bactericera albiventris* and *Trioza urticae*, overwinter on *Pinus* in northern England at a distance of around 13km from the nearest host plant (Hodkinson 1972,

1983c). *Trioza apicalis* similarly moves up to 1km on to its overwintering shelter plants (Kristoffersen and Anderbrant 2007).

Tropical forest species may also move considerable distances. The coastal mangrove-feeding *Limbosylla lagunculariae* has been taken inland in central Panama, many kilometres from the coast (Brown and Hodkinson 1988). Populations of *Boreioglycaspis melaleucae*, newly introduced for the biological control of *Melaleuca*, spread at a rate of up to 10km per year. Further testimony to the rapid dispersal powers of psyllids is the time (<10 years) in which *Heterosylla cubana* spread from an origin in Central America to colonize virgin plantings of its forage legume host *Leucaena leucocephala* in the Pacific, Asia, Australia and Africa (Hodkinson 1988b).

Experimental studies suggest that in species such as *Arytainilla spartiophila*, *Acizzia russelli* and *Trioza erythrae* females disperse further than males, as evidenced by an increase in the female: male sex ratio with increasing distance, 90–1500m depending on species, from the source (Dempster 1968; Webb 1977; van den Berg and Deacon 1988). However, this would be an ineffectual strategy in species with a post-dispersal ovarian diapause. For psyllids living on short herbaceous plants, such as *Trioza urticae*, the effective dispersal boundary layer, within which most directed dispersal movements take place, is probably less than 1m (Omole 1980). It is the individuals that stray above this height that are more likely to be wind dispersed.

#### *Adaptive significance of dispersal*

Multivoltine psyllids often show differences in dispersal behaviour among generations. Summer and autumn emerging adults of *Cardiaspina densitexta* in Australia, for example tend to show what White (1970c) calls “concentrative” behaviour. Adults blown out of a given *Eucalyptus* tree usually fly back into the same tree, and appear to neglect adjacent trees with significantly lower populations. This results in some trees supporting high psyllid densities while other nearby trees have low-density populations. By contrast, long-distance “dispersive” behaviour is a characteristic feature of the spring generation that has developed at shorter day length and lower temperatures. This parallels certain multivoltine north temperate species, such as *Cacopsylla pyricola* in which the winter morph, with its relatively longer wings produced under short day length, shows significantly greater dispersive behaviour than the spring or summer generation (Hodgson and Mustafa 1984; Horton, Burts, et al. 1994). The actual duration of the flight activity period is similar in the two morphs but flight frequency is much greater in the former (Horton and Lewis 1996). The actual rate of dispersal of these winter forms out of pear orchards tends to be correlated with the rate of leaf fall, lower temperature and density (Fye 1983; Horton, Burts, et al. 1994).

Univoltine species moving onto overwintering shelter plants, by comparison, exhibit both an autumn and a spring period of peak dispersal as they move to and from their winter host. Where significant dispersal occurs in summer generations, as in *Arytainilla spartiophila*, *Acizzia russellae* and *Trioza erythrae* it is usually associated with interspecific competition arising from high populations and declining host-plant favourability or increasing pressure from natural enemies (Dempster 1968; Webb 1977; van den Berg, Anderson, et al. 1991). Psyllids disperse to new, more favourable plants.

Dispersal opens up the opportunity for host-plant alternation in multivoltine psyllids but this behaviour, so typical of many aphid species, is rare in psyllids, with just two known examples. *Bactericera crithmi* on Malta undergoes a winter generation on *Ferula* during the period when its normal host *Crithmum* is dormant (Mifsud 1997). It moves back to *Crithmum* in spring. Similarly, the vector of psyllid yellows disease of potato, *Bactericera cockerelli* overwinters as source populations on *Lycium* and other wild Solanaceae in the warmer southern USA. In spring there is a general northwards wind-assisted dispersal of adults to establish sink populations breeding on potato (*Solanum*) in regions far to the north (Knowlton 1933; Knowlton and Thomas 1934; Swenk and Tate 1940; Wallis 1946, 1955).

Dispersal allows psyllids to track spatial and temporal changes in the availability of host-plant tissues suitable for growth and development. Many psyllids require flushes of young, rapidly growing leaf tissues on which to breed. As these leaves mature they become unsuitable for psyllid development and the psyllid must seek out new breeding sites. This is most acute where individuals of particular tree species drop leaves completely but asynchronously. In some Australian species, such as *Cardiaspina densitexta* and *C. albitextura*, this can result in progressive waves of psyllid outbreak and decline spreading across the landscape as psyllids track the flushing pattern of their host *Eucalyptus* (Morgan 1984). This precludes the need for diapausing stages. The problem may be particularly acute for tropical rainforest psyllids where individual host plants are usually sparsely distributed within a highly species diverse tree community and often flush asynchronously. A high level of dispersive behaviour by psyllids is necessary constantly to track the spatial and temporal availability of their food resource (Brown and Hodkinson 1988; Hodkinson and Casson 2000).

Even in temperate regions individual host plants may vary markedly in suitability between successive years. Many species of Rosaceae, for example, exhibit biennial or irregular patterns of flowering by individual plants that may affect their suitability as psyllid hosts (Sutton 1984). It is unsurprising, therefore, that highly dispersive psyllids like *Cacopsylla melanoneura* and *C. affinis* are associated with one such rosaceous plant species, namely *Crataegus* (Sutton 1984).

### **Overwintering on shelter plants**

Many temperate species of psyllids are known to disperse to, and overwinter as adults on, evergreen shelter plants before moving back onto their true host in the spring (Reuter 1909; McAtee 1915; Hodkinson 1972; Hågvar and Hågvar 1975; Kristoffersen and Anderbrandt 2007) (Table 1). Such hosts are usually conifers, primarily species of *Pinus*, *Picea*, *Abies*, *Taxus*, *Tsuga*, *Cupressus* and *Juniperus* but may also include thorny evergreen shrubs such as *Ulex*. In *Trioza apicalis* there appears to be a distinct order of preference, with *Picea* supporting higher populations than *Pinus* or *Juniperus* (Kristoffersen and Anderbrandt 2007). The period spent on shelter plants, which usually matches periods when the host is dormant or unfavourable for psyllid development, is normally accompanied by an ovarian diapause. This adaptive overwintering strategy is found in almost all temperate psyllid families but is most frequent among species of *Aphalara*, *Livia*, *Cacopsylla*, *Bactericera*, *Phylloplecta* and *Trioza*. It is, however, recorded more sporadically in a wider range of genera including *Pachypsylla*, *Calophya*, *Camarotoscena*, *Togepssylla*, *Ligustrinia*, *Cyamophila*, *Livilla* and *Epitrioza* (Table 1).

Psyllids on conifers are easily caught and observed whereas those overwintering in leaf litter or grass tussocks are much less obvious. Careful studies on some species such as *Bactericera perrisi*, *Aphalara avicularis*, *A. exilis* and *A. longicaudata* show that individuals overwinter both on conifers and in litter, perhaps raising the question for other species of what actual proportion of the overwintering population is on conifers (Lauterer 1976, 1982, 1991). Furthermore, several species of *Aphalara*, *Cacopsylla* and *Trioza*, known to overwinter on conifers, can also be overwintered successfully in grass tussocks maintained in pots (Heslop-Harrison 1937). These individuals tend to be much lighter coloured than those spending winter on conifers (Heslop-Harrison, 1937).

One question that has not been fully answered is whether overwintering psyllids feed on conifers or other shelter plants. Experiments in our laboratory using *Pinus* shoots labelled with  $C_{14}$  and  $P_{32}$  repeatedly failed to provide definitive evidence for winter feeding by *Cacopsylla melanoneura*, although the maintenance of body condition and levels of hydration suggest that some feeding must take place (Jackson et al. 1990). There is, however, some evidence that overwintering *Cacopsylla pyricola* may feed on transitory hosts such as *Prunus persica* (Ullman and McLean 1988b).

#### ***Mate finding and aggregation on host plants***

Small dispersive insects, such as psyllids, are faced with the problem of finding suitable mates, either on their breeding or overwintering host plants. Species are frequently found as highly-aggregated, mixed-sex colonies on the tissues of their host. Several are known to emit species- and gender-specific stridulation calls or to make drumming sound or vibrations with their tarsi on leaf surfaces (Campbell 1964; Ossiannilsson 1950; Heslop-Harrison 1961; KL Taylor 1985; Carver 1987; Tishechkin 1989, 2005, 2007; Percy et al. 2006), which are thought to aid mate location and aggregation. There is also some evidence for chemical mechanisms leading to aggregation and mate finding. Male *Cacopsylla pyricola* are attracted to volatile chemicals emanating from pear shoots with receptive post-diapause females present or from shoots that have recently supported populations of such females. The precise nature of the chemical stimulus is unknown and it remains to be determined whether the chemicals involved originate from the psyllid, the host plant, or a combination of both (Horton et al. 2007; Horton and Landolt 2007). However, in some other species, such as *Cardiaspina albitextura*, host-plant tissues previously occupied by psyllids appear less favourable for oviposition than formerly unfrequented sites (Clark 1962, 1963b).

#### ***Variation in fecundity among species***

It might be predicted that the fecundity of psyllid species is related to their type of life cycle, with species having larvae living in protective galls or lerps producing fewer eggs than those living on exposed growing tips. There is, however, surprisingly little pattern in the fecundity of psyllid species (Table 3). Experimentally measured fecundity differs widely, even among species within the same genus or family. Where repeated measures have been made on the same species in different localities or at different times, such as in *Trioza erythrae*, *Heteropsylla cubana* or *Diaphorina citri*, mean fecundity may differ by a factor of two or more (Table 3). Furthermore, there is little to suggest major differences in fecundity related to taxonomic position.

Table 3. Fecundity of selected psyllid species on preferred host, illustrating variation in potential reproductive output across the group. Numbers given are mean and maximum egg production per female under non-limited experimental conditions.

Family	Species	Maximum	Mean	Reference
Psyllidae	<i>Aphalara</i> <i>polygona</i>		c. 300	Lauterer (1982) (as <i>rumicicola</i> )
	<i>Paurocephala</i> <i>psylloptera</i>		640 <sup>†</sup>	Hsieh and Chen (1977)
	<i>Diclidophlebia</i> <i>eastopi</i>		502	Osisanya (1974a)
	<i>Diclidophlebia</i> <i>harrisoni</i>		131	Osisanya (1974a)
	<i>Diclidophlebia</i> <i>xuani</i>		532–758	Aléné et al. (2005a)
	<i>Ctenarytaina</i> <i>thysanura</i>		86–92	Mensah and Madden (1992a, 1993b)
	<i>Agonoscena</i> <i>pistaceae</i>		893–1087	Mehrnejad and Copland (2005)
	<i>Gyropsylla</i> <i>spgazziniana</i>	180	108*	Leite and Zanol (2001)
	<i>Diaphorina citri</i>	807	630 <sup>†</sup>	Hussain and Nath (1927)
	<i>Diaphorina citri</i>		748	Liu and Tsai (2000)
	<i>Diaphorina citri</i>		858	Tsai and Liu (2000)
	<i>Diaphorina citri</i>	700	266	Mangat (1966)
	<i>Diaphorina citri</i>	520	210–300	Pande (1971)
	<i>Cacopsylla</i> <i>melanoneura</i>	116	84	Domenichini (1967)
	<i>Cacopsylla</i> <i>pyricola</i>		664	Burts and Fischer (1967)
	<i>Cacopsylla</i> <i>pyricola</i>		445	McMullen and Jong (1977)
	<i>Cacopsylla</i> <i>pyricola</i>		665	Rasmy and MacPhee (1970)
	<i>Cacopsylla</i> <i>pyricola</i>		387–486	An et al. (1996)
	<i>Cacopsylla pyri</i>		47–406	Kapatos and Stratopoulou (1996)
	<i>Cacopsylla pyri</i>	2527		Lyousoufi et al. (1988)
	<i>Cacopsylla pyri</i>		471	Nguyen (1970a)
	<i>Cacopsylla pyri</i>		588	Nguyen (1973)
	<i>Acizzia</i> <i>uncatoides</i>		463 <sup>†</sup>	Koehler et al. (1966)
	<i>Acizzia</i> <i>uncatoides</i>		986	Madubuny and Koehler (1974)
	<i>Arytaina genistae</i>	962	435	Watmough (1968a)
	<i>Arytainilla</i> <i>spartiophila</i>	354	93	Watmough (1968a)
	<i>Heteropsylla</i> <i>cubana</i>		758	Patil et al. (1994)

Table 3. (Continued.)

Family	Species	Maximum	Mean	Reference
	<i>Heteropsylla cubana</i>	857	394	Takara et al. (1990)
	<i>Heteropsylla texana</i>	100		Donnelly (2002)
Spondyliaspidae	' <i>Psylla</i> ' <i>isitis</i>	828	479 <sup>†</sup>	Grove and Gosh (1914)
	<i>Euphalerus clitoriae</i>		1148	Junior et al. (2005)
	<i>Cardiaspina albitextura</i>	220	124*	Clark (1962, 1963b)
	<i>Cardiaspina albitextura</i>	290	45	Morgan and Taylor (1988)
	<i>Boreioglycaspis melaleucae</i>		78	Purcell et al. (1997)
Calophyidae	<i>Apsylla cistellata</i>		141–150	Monobrullah et al. (1998)
	<i>Apsylla cistellata</i>		141	Prasad (1957)
Carsidaridae	<i>Carsidara limbata</i>	1701		Ding et al. (1987)
	<i>Allocarsidara malayensis</i>		50	Gadug and Hussein (1987)
	<i>Mesohomotoma tessmanni</i>	61	48 <sup>†</sup>	Igboekwe and Adenuga (1983)
Triozidae	<i>Phylloplecta tripunctata</i>	202	94–164	Petersen (1923)
	<i>Trioza erytreae</i>	560	327	Moran and Blowers (1967)
	<i>Trioza erytreae</i>		787	Van den Berg, Deacon and Thomas (1991a)
	<i>Trioza erytreae</i>		827	Van den Berg (1990)
	<i>Trioza eugeniae</i>	331	198	Young (2003)
	<i>Trioza hirsuta</i>	180	99	Dhiman and Singh (2004)
	<i>Trioza magnicauda</i>		692	Chang et al. (1995)
	<i>Bactericera cockerelli</i>	1176	439	Pletsch (1947)
	<i>Bactericera cockerelli</i>	1300	318	Knowlton and Janes (1931)
	<i>Bactericera tremblayi</i>	803	431	Tremblay (1965b)
	<i>Schedotrioza multitudinea</i>		487	GS Taylor (1985, 1987)
	<i>Trichohermes walkeri</i>	279	201	McLean (1998)
	<i>Neotrioza taveresi</i>		219	Butignol and Pedrosa (2003)
	<i>Pauropsylla depressa</i>		>150	Abbas (1967)

Note: occasionally, where means were not calculated in the original paper, they are calculated as (minimum+maximum)/2 (indicated by\*); alternatively, some means (indicated by<sup>†</sup>) are calculated directly from raw data given in the original paper; a range of values indicates recorded differences in means among seasons.

Typically mean fecundity per female ranges from 40–50 to over 1000, with a majority of species lying within the range 200–800. Lowest values (40–50) occur in some but not all Spondyliaspidae and Carsidaridae but highest values are often found in pest species of Psyllidae and Triozidae such as *Agonoscena pistaciae*, *Trioza erythrae* and *Bactericera cockerelli* in which some individual females produce up to 1300 eggs.

Oviposition usually occurs over an extended period with females often maturing successive batches of eggs (An et al. 1996; Dhiman and Singh 2004). In species such as *Cacopsylla pyricola*, *Trioza erythrae* and *Agonoscena pistaciae*, repeated mating is necessary for a female to produce a full egg complement (Burts and Fischer 1967; van den Berg, Deacon and Thomas 1991a; Mehrnejad 1998; Mehrnejad and Copland 2006a), emphasizing the importance of continuous mate finding for successful life cycle completion.

#### *Factors influencing fecundity*

Several factors influence fecundity, including temperature, day-length and season, host condition and crowding. Fecundity, as noted earlier, tends to decline above and below an optimum temperature, as in *Acizzia uncatoides*, *Agonoscena pistaciae*, *Cacopsylla pyri* and *Bactericera cockerelli* (List 1939a; Madubunyi and Koehler 1974; Nguyen 1970a; Mehrnejad and Copland 2006a). In multivoltine species such as *Agonoscena pistaciae*, *Diclidophlebia xuani*, *Cacopsylla pyri*, *Cacopsylla pyricola* egg output per female also varies significantly between seasons, with day length as well as temperature often an important determining factor (Nguyen 1970a; Kapatos and Stratapoulou 1996; Mehrnejad and Copland 2005; Aléné et al. 2005b). Moderate crowding initially enhances fecundity in species such as *Trichohermes walkeri*, *Cardiaspina albitextura*, *Cacopsylla pyri* and *Arytaina genistae* but increasing density beyond the optimum leads to declining fecundity (Watmough 1968a, 1968b; Clark 1963a; Nguyen 1971, 1973; McLean 1998). The presence of eggs also acts as a deterrent to oviposition in *Trioza eugeniae* (Luft and Paine 1997).

The previous discussion of life history parameters shows that psyllid species exhibit considerable variation in their life history characteristics and their adaptive response to their environment. It is now appropriate to examine the distribution of characteristics across the Psylloidea and to identify how the life cycle parameters are combined within the life histories of species both within and among higher taxa.

#### **Analysis of psyllid life history characteristics**

Table 1 shows the detailed life history characteristics of 342 psyllid species culled from the literature. Species are arranged in descending taxonomic sequence by family, tribe and genus. The key references from which data are drawn are listed. In the large genus *Cacopsylla* the *Salix*-feeding species with similar life histories are separated from the other species, which themselves are split into subgenera. Information is provided for each species on the major climatic zone within which it is found, the functional growth form of its host plant, the overwintering stage(s), the overwintering site, either on or off the host, voltinism, feeding site on the host and whether or not the larva forms galls of a particular type or lerps on the host plant. A full explanation of the various life history categories and their abbreviations as used in this table are listed in the note of Table 1.

**Methods of coding and analysis**

The categorical life history data in Table 1 were numerically coded as the basis for a full analysis of the dataset, with each category of each characteristic given a separate numerical code. Voltinism presented a slight problem of coding and species were coded as semivoltine, univoltine or multivoltine, depending on the maximum life history duration. Taxonomic status of the psyllids was coded at the family, tribe and genus level. The basic objective of the analyses was to test whether there were recognisable and consistent patterns in the data linking particular life history traits with specific psyllid groups.

Three separate multivariate analyses were employed to explore the structure of the dataset using the MINITAB 14 statistical package, namely Multiple Correspondence Analysis (MCA), Linear Discriminant Analysis (LDA), and Cluster Analysis (CA) of both the descriptive variables and of the species.

MCA attempted to measure the extent to which different characters correspond with each other across the dataset and whether particular sets of characteristics correspond to particular taxonomic groupings within the psyllids. Analyses were initially conducted using life history characters alone to explore relationships among these variables and then repeated with psyllid groupings added. These analyses used the full dataset for all species.

LDA tests whether suggested groupings of species are justified on the basis of the measured life history variables. This analysis was conducted three times using genus, tribe and family as the suggested species grouping. The output displays how many species are correctly or incorrectly allocated objectively to the proposed grouping. A high level of correct prediction indicates that life history characteristics tend to be relatively uniform within the group and are good predictors of taxonomic position. A low level suggests that life history characteristics are highly variable within proposed groups and thus poor predictors. This may, however, indicate greater adaptive flexibility as species have evolved differing life cycles to exploit varying opportunities within different environments. In conducting these analyses it is necessary to remove monobasic genera and tribes from the dataset, where necessary, as a single taxon cannot form a group.

CA measured similarity among taxa or among variables within the main dataset using Euclidean distance: clustering was by average linkage.

**Results of analyses**

CA of variables (Figure 1) indicates two major groupings of characters and two outliers. The first grouping links voltinism and overwintering stage, not unexpectedly, to climate. The second links feeding site and overwintering site to plant functional type. The two outlying characters are gall type and lerp formation. Their separation from other characters appears to lie in the fact that lerp formation is largely concentrated within one family, the Spondyliaspidae, while gall instigation/type is spread broadly but rather haphazardly across taxa.

Overall, the level of correspondence among characters in MCA (Table 4) was low, with cumulative correspondence across species along the first five axes totalling only 26%. Introducing psyllid tribe as an additional character actually reduced correspondence further (19%). Gall and lerp formation were again the main outlying characters.



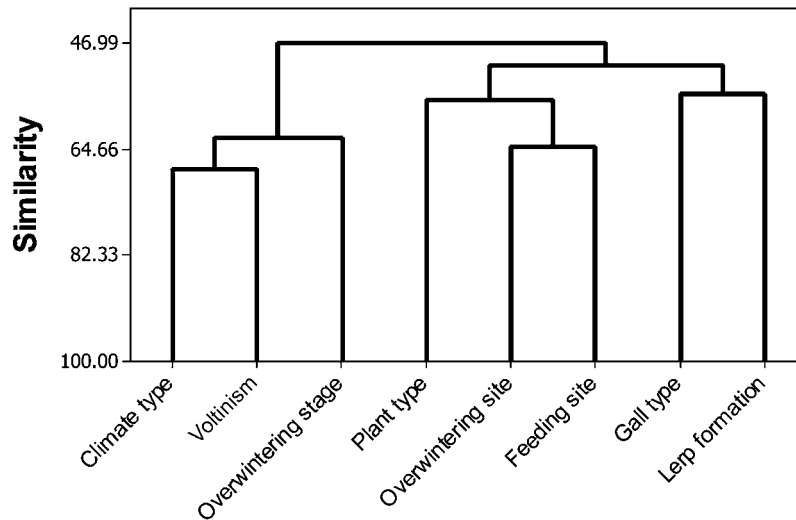


Figure 1. Dendrogram illustrating the level of correspondence among life history parameters measured across psyllid species. Note: similarity is measured by Euclidean distance; clustering is by average linkage.

The total percentage of species allocated to the correct tribe by LCA was generally around a weighted mean of 47% (Table 5) but this hid wider variation among taxa, with one large group the Triozini in particular, dragging the total down but with other smaller tribes, such as Acizziini, Gyropsyllini, Mastigimatini and Phytolymini, showing good predictability. However, the correlation between group size and predictability (%) was non-significant ( $r=0.01$ ,  $p>0.05$ ). Despite wide variability among taxa, predictability increased stepwise from the genus ( $n=302$ , 40% correct) to the family level ( $n=322$ , 50% correct). This suggests that differentiation and thus discrimination among taxa, related to life history traits, increases with taxonomic level.

**Discussion and conclusions**

Within the Psylloidea there is considerable variation in the body form of the larvae related to phylogeny and one might predict that particular physiognomies are best

Table 4. Results of multiple correspondence analysis across species showing percentage of cumulative correspondence explained by the first five axes.

	Cumulative Variation (%)				
	Axis				
Character set	1	2	3	4	5
Excluding tribe	7	13	17	22	26
Including tribe	5	9	12	16	19

Note: analyses are presented both with and without the inclusion of psyllid tribe as a character.

Table 5. Percentage of species allocated to their correct tribe using linear discriminant analysis based on life history characteristics. *n* is the number of species on which the percentage is based.

	<i>n</i>	% correct
Acizzini	3	100
Aphalarini	27	67
Arytainini	25	16
Calophyini	7	43
Ciriacremini	3	0
Ctenarytainini	4	25
Diaphorinini	3	33
Diclidophlebiini	7	100
Euphalerini	4	0
Euphyllurini	6	17
Gyropsyllini	2	100
Liviini	4	75
Mastigmatini	2	100
Mesohomotomini	2	50
Pachypsyllini	8	13
Pachypsylloidini	11	100
Paurocephalini	3	66
Pauropsyllini	6	33
Phytolymini	2	100
Psyllini	72	68
Psyllopseini	9	89
Rhinocolini	6	33
Spondyliaspidini	11	91
Strophingiini	2	100
Triozini	86	16
<b>Total</b>	<b>315</b>	<b>47</b>

adapted to exploiting plants in different ways (Loginova 1982; White and Hodkinson 1985). Thus, for example, larvae of many Triozidae and Calophyidae are strongly flattened and rounded and one might expect them to be best adapted for a sedentary existence, living on the surface of leaves or within open pit galls on the leaf surface. By contrast, larvae of many Psyllidae and Spondyliaspididae are less flattened and more robust, with relatively longer legs. They appear best adapted for a free living existence on expanding shoots or developing within larger enclosed leaf galls. While many species conform to this expected typology others do not. Thus, many Triozidae and Calophyidae live on growing shoots or within enclosed galls while several Psyllidae form pit galls and many Spondyliaspididae live on leaf surfaces. It is against this phylogenetic history that interpretations and conclusions regarding psyllid life history adaptations can now be made.

Several important conclusions can be drawn from the analyses of the life history data. Firstly, and perhaps most significantly, the linkage between phylogenetic grouping and life history characteristics, while discernible, is not of overriding significance in determining the type of life history a psyllid undergoes. The phylogenetic signal, as revealed by MCA is marginally stronger at the family level

than at the generic level but at best only explains about a quarter of the total variation observed. Similarly, LDA on average, using life history characteristics as predictors, only allocates species to the correct genus, tribe or family group with at best 50% mean accuracy. This again suggests high within group variation in life history characteristics, even at ascending taxonomic levels. However, within these average figures there do appear to be individual taxa that display a higher level of predictability, such as *Craspedolepta*, *Aphalara* and *Psyllopsis*, but this is compensated for by others such as the large genus *Trioza* that show low predictability. Nevertheless, these general findings accord with Danks (2006, p. 9) who reviewed published data on life history traits across the Insecta. He concluded that: "...phylogenetic history of a group or species does determine the core structure of seasonal responses... but that perhaps more striking is the large number of traits linked to habitat or its seasonal components that have evolved many times independently." Among such traits he lists diapause, cold-hardiness, reproductive pattern, paedogenesis, gall formation etc. (see also Danks (2002, 2005, 2007)). He concludes (2006, p. 9) that: "...how the different responses are integrated to provide coherent, seasonally relevant development trajectories can be understood only by reference to ecological demands."

Extending these conclusions to the psyllids we can observe the manner in which environmental and host-plant factors overlay the phylogenetic signal to produce the wide variation observed in psyllid life history traits observed today. Thus, the CA for life history variables recognizes two major groupings of linked parameters. First, voltinism and overwintering stage is linked to climatic environment. Second, larval feeding site and overwintering site is linked to plant functional type. Gall formation, by contrast appears to have evolved independently on several occasions across disparate psyllid taxa. Lerp formation is more tightly constrained within the family Spondyliaspidae. It should be noted, however, that plant functional type is itself largely a plant response to climate.

It now becomes possible to suggest how environmental and ecological constraints have led to the observed diversification of psyllid life histories and to draw together the various threads into a coherent exposition of psyllid life history adaptation on a global stage. Global temperature and moisture gradients and the adaptive biology of host plants provide the backdrop against which such psyllid adaptations have evolved.

Psyllid species living within tropical moist habitats, as typified by lowland tropical rainforest, probably suffer the least constraint on their development. They are usually associated with *evergreen* phanerophytes and chamaephytes, undergo continuous reproduction and are thus typically multivoltine. However, even in these benign habitats, host tree species frequently display cycles of flushing of suitable tissues for larval development, with individual trees at different stages of the flushing cycle at any one time. In such high diversity forests, a continuous life cycle demands continuous and effective population dispersal to seek out the sparsely distributed trees of the host species in an appropriate phenological state for reproduction to continue (Hodkinson and Casson 2000; Brown and Hodkinson 1988). It may also select for small and highly dispersive species (Hodkinson and Casson 2000).

In tropical habitats with increasing seasonality of rainfall an increasing proportion of host tree and shrub species are *deciduous*, with some host species being leafless for several months of the year and some tree species showing various

levels of deciduousness between individuals. Under these circumstances adult and/or egg diapause allows associated psyllids, independent of taxonomic provenance, to arrest their life cycle and thereby align development with the phenology of their host, but at the expense of a reduced number of generations per year. As tropical habitats become even more seasonally dry then deciduousness among hosts becomes the norm and seasonal diapause responses assume even greater significance for psyllid survival. Here again successful dispersal over a wide area may be necessary to relocate hosts following periods of inactivity.

As one moves from the wet tropics into the moist temperate regions or at higher altitudes within the tropics a number of developments and trends in psyllid life cycles are observed. There is a general reduction in the temperature threshold for development, development rates are often slower, voltinism is reduced and life histories become strongly seasonal, with developmental or reproductive diapause becoming increasingly important for maintaining developmental synchrony with the host plant. Some species display morphologically distinct seasonal forms. Winter survival mechanisms, involving increased levels of cold-hardiness, assume increasing significance. There is also an increase in the availability and use of herbaceous host-plant species falling within the hemicryptophyte and geophyte functional categories. Typically the growing tips of these plants overwinter at or below the soil surface, produce a flush of growth each year and then die back in the autumn. This necessitates a psyllid overwintering strategy that involves movement onto the winter bud or root or hibernation away from the host plant and movement back onto the new foliage in spring.

Psyllids living on temperate phanerophytes and chamaephytes have alternative life history possibilities. Many psyllid species on *deciduous* phanerophytes overwinter as diapausing eggs on the buds or apical shoots where they are exposed to the full rigours of winter. Hatching is timed to coincide with spring bud burst. Alternatively, adults may overwinter either on the host or on shelter plants. In both cases a reproductive diapause is necessary to delay oviposition until the spring growth of the plant commences. Movement onto and from winter shelter plants necessitates the development of two phases of pre-reproductive dispersal in autumn and spring.

On *evergreen* phanerophyte/chamaephyte species many psyllid species overwinter as diapausing larvae on the green shoots or leaves. On such plants the requirement for precise phenological synchrony with plant growth is less demanding as larval growth simply recommences as shoots or leaves resume growth in the spring. Development time can, as a consequence, be potentially extended beyond one year. Overwintering as mixed populations of eggs, larvae and adults also becomes feasible on such plants.

Within temperate regions, where rainfall becomes strongly seasonal, as in areas of Mediterranean climate, periods of psyllid development and reproduction often become compressed into the short period of the year, such as early spring, when temperatures are sufficiently high but not too hot and when rainfall is adequate to stimulate the flushing of new plant growth. Such compression of life histories, with long periods of spent inactive as diapausing eggs, larvae or adults, becomes even more pronounced in psyllid species associated with host plants growing in steppe and desert environments.

As one moves north from the temperate to the cold boreal regions psyllid faunas become much less diverse and individual species are usually associated with

prominent host taxa such as *Salix*, *Alnus* and *Betula* on which they typically undergo rapid annual life cycles during a short summer growing period. These woody host plants almost invariably exhibit a low chamaephyte growth form: other herbaceous hemicryptophytes and geophytes appear less commonly as hosts. Overwintering is either as eggs on growing shoots or as adults that overwinter in leaf litter around the base of the plants, often covered by a protective snow layer.

It is reasonable to conclude on the previous evidence that the two prime environmental variables, temperate and moisture availability, acting within an ecological context, are either directly, or mediated through the physiognomy and ecological adaptations of host plants, the major pressures acting on the evolution of psyllid life histories. Together they have frequently resulted in similar strongly convergent life histories across taxonomically disparate sets of psyllid species and divergent life histories among related species. Danks's (2006) conclusions regarding the comparatively low importance of group phylogenetic history in determining life history parameters are well supported by the psyllid data.

## References

- Abbas SR. 1967. Biology of *Pauropsylla depressa* Crawford (Homoptera: Psyllidae). *Cecidologica Indica* 2:43–52.
- Akanbi MO. 1980. Preliminary notes on *Triozaambia lamborni*: a potentially dangerous pest of *Antiaris africana*. *Entomol Mon Mag.* 116:113–115.
- Aléné DC, Messi J, Quilici S. 2005a. Contribution a la connaissance de la faune d'arthropodes associée a *Ricinodendron heudelotii* Baill. (Euphorbiaceae) au Cameroun. *Fruits* 60:121–132.
- Aléné DC, Messi J, Quilici S. 2005b. Quelques aspects de la biologie de *Diclidophlebia xuani* Messi et al. (Hemiptera: Psyllidae), ravageur de *Ricinodendron heudelotii* Baill. (Euphorbiaceae) au Cameroun. *Fruits* 60:279–287.
- Aléné DC, Messi J, Quilici S. 2006. Influence of shade on the sensitivity of seedlings of *Ricinodendron heudelotii* (Baill.) to attacks of *Diclidophlebia xuani* Messi et al. in the natural environment in Cameroon. *Fruits* 6:273–280.
- An JH, Yiem MS, Kim DS. 1996. Effects of photoperiod and temperature on formation and fecundity of two seasonal forms of *Psylla pyricola* (Homoptera: Psyllidae). *Korean J Appl Entomol.* 35:205–208.
- André E. 1878. Mémoire pour servir a l'histoire de la la *Trioza centranthi* Vallot. *Annal Soc Entomol Fra.* 8:77–86.
- Annunziata F di, Clemente N. 1980. La psilla della cipollo (*Trioza tremblayi* Wagn.). *Inf Agrar.* 36:10159–10161.
- Anon. 1988. Citrus greening bacterium and its vectors *Diaphorina citri* and *Trioza erytreae* (Homoptera Psyllidae). *Bull OEPP* 18:497–508.
- Arai Y. 1991. On the habitat of the adult of the mulberry sucker in winter *Anomoneura mori* Schwarz (Homoptera Psyllidae). *J Seric Sci Jpn.* 60:390–393.
- Arai Y. 1993. Observation on the mating behavior of the mulberry sucker, *Anomoneura mori* (Homoptera: Psyllidae). *J Seric Sci Jpn.* 62:297–302.
- Arambourg Y, Chermiti B. 1986. Psyllidae. Traite d'entomologie oleicole. Madrid (Spain): Conseil Oleicole International.
- Arzone A, Vidano C. 1985. Il fitomiza *Psylla uncatoides* su mimosa in Liguria. *Inf Fitopatol.* 35:31–34.
- Ashmead WH. 1881. On the Aphididae of Florida with descriptions of new species (Family Psyllidae). *Can Entomol.* 13:220–225.
- Ashmole NP, Ashmole MJ. 1988. Insect dispersal on Tenerife, Canary Islands: high altitude fallout and seaward drift. *Arctic Alpine Res.* 20:1–12.

- Ashmole NP, Ormomi P, Ashmole MJ, Martin JL. 1996. The invertebrate fauna of early successional volcanic habitats in the Azores. *Bol Mus Municipal Funchal*. 48:5–39.
- Atger P. 1982. *Le psylle du poirier*. Paris (France): Centre Technique Interprofessionnel des Fruits et Légumes.
- Atwal AS. 1962. Insect pests of citrus in the Punjab. Vol 1. Biology and control of citrus psylla *Diaphorina citri* Kuwayama (Hemi: Psyllidae). *Punjab Hort J*. 2:104–108.
- Atwal AS, Chaudhary JP, Ramzan M. 1970. Studies on the development and field population of citrus psylla *Diaphorina citri*. *J Res Punjab Agric Univ*. 7:333–338.
- Austin MT, Williams MJ, Hammond AC, Frank JH, Chambliss CG. 1996. Psyllid population dynamics and plant resistance of *Leucaena* selections in Florida. *Trop Grasslands*. 30:223–228.
- Awadallah KT, Swailem SM. 1971. On the bionomics of the sycamore-fig psyllid *Pauropsylla trichaeta*. *Bull Soc Entomol Egypt*. 55:193–199.
- Azevedo F, Figo ML. 1979. *Ctenarytaina eucalypti* Mask (Homoptera, Psyllidae). *Boletino Servicio de Plagas Forestales* 5:41–46.
- Balachowsky A, Mesnil L. 1936. *Les insectes nuisibles aux plantes cultivées*. Vol. 2. Paris (France): Mery.
- Baldassari N, Baronio P, Rocchetta G, Salvaterra I. 1996. Research on the development of *Cacopsylla pyri* (L.) (Homoptera Psyllidae) on different mutants and selections of pear. *Boll Ist Entomol "Guido Grandi" Univ Stud Bologna*. 50:201–213.
- Baloch GM, Ghaffar A. 1984. Natural enemies of *Chenopodium* spp in Pakistan with notes on *Trioza chenopodii*, a promising biocontrol agent. *Entomophaga* 29:409–414.
- Basset Y. 1991. The taxonomic composition of the arthropod fauna associated with an Australian rainforest tree. *Aust J Zool*. 39:171–190.
- Beeson CFC. 1941. *The ecology and control of the forest insects of India and the neighbouring countries*. Dehra Dun (India): Vasant Press.
- Ben Khalifa M, Marrakchi M, Fakhfakh H. 2007. Candidatus Phytoplasma pyri infections in pear orchards in Tunisia. *J Plant Pathol*. 89:269–272.
- Berrada S, Nguyen TX, Lemoine J, Vanpoucke J, Fournier D. 1995. Thirteen pear species and cultivars evaluated for resistance to *Cacopsylla pyri* (Homoptera: Psyllidae). *Environ Entomol*. 1995:1604–1607.
- Bertaux F, Phalip M, Martinez M, Schumacher J-C. 1996. Le psylle de l'eucalyptus, nouveau ravageur des eucalyptus en France. *Phytoma –Defense Veg*. 487:48–50.
- Bey NS. 1931. Untersuchungen uber Mohrenblattsauger. *Z Angew Entomol*. 18:175–188.
- Biase LMD. 1983. La *Trioza* (*Bactericera*) *nigricornis* Forst e la *Trioza trigonica* Hod (Homoptera Psylloidea) nel fucino. *Difesa Pianta*. 2:103–110.
- Bigornia AE, Obana SP. 1974. Studies on the population dynamics of *Diaphorina citri* (Kuway.) and the flushing rhythm of citrus. *Philipp J Plant Ind*. 39:37–52.
- Bin F. 1970. *Lygus viscicola* Put. (Miridae) e *Psylla visci* Curt. (Psyllidae) rincoti del vischio nuovi per la fauna italiana. *Boll Zool Agrar Bachic*. 10:133–143.
- Bin F. 1972. Presenza in Italia della *Trioza femoralis* Foerster e notizie su due calcidoidei suoi parassiti. *Entomologica, Bari* 8:45–53.
- Bird JM, Hodkinson ID. 1999. Species at the edge of their range: the significance of the thermal environment for the distribution of congeneric *Craspedolepta* species (Sternorrhyncha: Psylloidea) living on *Chamerion angustifolium* (Onagraceae). *Eur J Entomol*. 96:103–109.
- Bird JM, Hodkinson ID. 2005. What limits the altitudinal distribution of *Craspedolepta* species (Sternorrhyncha: Psylloidea) on fireweed? *Ecol Entomol*. 30:510–520.
- Blomquist CL, Kirkpatrick BC. 2002. Identification of phytoplasma taxa and insect vectors of peach yellow leaf roll disease in California. *Plant Dis*. 86:759–763.
- Blowers JR, Moran VC. 1968. Notes on the female reproduction system of the South African citrus psylla, *Trioza erytrae* (Del Guercio) (Homoptera: Psyllidae). *J Entomol Soc South Afr*. 36:71–81.

- Bonnemaison L, Missonnier J. 1955a. Influence du photoperiodisme sur le déterminisme des formes estivales ou hivernales et de la diapause chez *Psylla pyri* (Homopteres). Comptes Rendus Acad Sci, Paris. 240:1277–1279.
- Bonnemaison L, Missonnier J. 1955b. Recherches sur le déterminisme des formes estivales ou hivernales et de la diapause chez le psylle du poirier (*Psylla pyri* L.). Ann Epiphyt C. 4:457–528.
- Bonnemaison L, Missonnier J. 1956. Le psylle du poirier (*Psylla pyri* L) morphologie et biologie, methodes de lutte. Ann Epiphyt. 2:263–331.
- Borelli N. 1920. Contributo alla conoscenza della vita nelle galle dell'alloro. Boll Soc Entomol Ital. 51:3–37.
- Boselli FB. 1929a. Studii sugli psyllidi I. Contributio alla conoscenza della psylle del fico (*Homotoma ficus* L.). Boll Lab Zool Gen Agrar Fac Agrar Portici 21:218–251.
- Boselli FB. 1929b. Studii sugli psyllidi IV. Biologia e sviluppo della *Spanioza gallii aspinovelutina* (Šulc). Boll Lab Zool Gen Agrar Fac Agrar Portici 23:13–27.
- Boselli FB. 1930. Studii sugli psyllidi (Homoptera: Psyllidae), VIII. Biologia e sviluppo della *Rhinocola succincta* Heeger. Boll Lab Zool Gen Agrar Fac Agrar Portici 24:211–222.
- Boselli FB. 1960. Studii sugli psyllidi (Homoptera: Psyllidae o Chermidae) XI. Biologia e sviluppo di *Diaphorina putoni* Loew specie nuova par la fauna italiana. Ann Sper Agri, Roma 14:149–156.
- Brennan EB, Hrusa GF, Weinbaum SA, Levison W. 2001. Resistance of *Eucalyptus* species to *Glycaspis brimblecombei* (Homoptera: Psyllidae) in the San Francisco Bay area. Pan-Pac Entomol. 77:249–253.
- Brennan EB, Weinbaum SA. 2001a. Effect of epicuticular wax on adhesion of psyllids to glaucous juvenile and glossy adult leaves of *Eucalyptus globulus* Labillardiere. Aust J Entomol 40:270–277.
- Brennan EB, Weinbaum SA. 2001b. Performance of adult psyllids in no-choice experiments on juvenile and adult leaves of *Eucalyptus globulus*. Entomol Exp Appl. 100:179–185.
- Brennan EB, Weinbaum SA. 2001c. Psyllid responses to colored sticky traps and the colors of juvenile and adult leaves of the heteroblastic host plant *Eucalyptus globulus*. Environ Entomol. 30:365–370.
- Brennan EB, Weinbaum SA. 2001d. Stylet penetration and survival of three psyllid species on adult leaves and “waxy” and “de-waxed” juvenile leaves of *Eucalyptus globulus*. Entomol Exp Appl. 100:355–363.
- Brennan EB, Weinbaum SA, Rosenheim JA, Karban R. 2001. Heteroblasty in *Eucalyptus globulus* (Myricales: Myricaceae) affects ovipositional and settling preferences of *Ctenarytaina eucalypti* and *C. spatulata* (Homoptera: Psyllidae). Environ Entomol. 30:1144–1149.
- Brèthes J. 1921. Un nuevo Psyllidae de la Republica Argentina (*Gyropsylla ilicicola*). Rev Facult Agron, Univ Nacion la Plata. 14:82–89.
- Brittain WH. 1922a. The adult habits of the apple sucker (*Psylla mali* Schmidberger). Sci Agri. 3:58–64.
- Brittain WH. 1922b. The apple sucker (*Psylla mali*). J Econ Entomol. 15:96–101.
- Brittain WH. 1923a. The European apple sucker. Bull Nova Scotia Dep Agri. 10:1–69.
- Brittain WH. 1923b. Injuries, life history and control of the apple sucker (*Psylla mali* Schmidberger). Sci Agri 3:176–188.
- Brocher F. 1926. Observations biologiques sur *Psylla pyrisuga* (Hemipt.). Ann Soc Entomol Fr. 95:183–188.
- Brown RG, Hodkinson ID. 1988. Taxonomy and ecology of the jumping plant-lice of Panama (Homoptera Psylloidea). Entomonograph. Vol. 9. New York: EJ Brill.
- Burckhardt D. 1999. *Cacopsylla pulchella* (Löw) a plant-louse species on *Cercis siliquastrum* from Basel (Homoptera, Psylloidea). Mitt Entomol Ges Basel 49:71–76.

- Burckhardt D. 2005a. *Ehrendorferiana*, a new genus of Neotropical jumping plant lice (Insecta: Hemiptera: Psylloidea) associated with conifers (Cupressaceae). *Org Divers Evol.* 5:317–319.
- Burckhardt D. 2005b. Biology, ecology, and evolution of gall-inducing psyllids (Hemiptera: Psylloidea). In: Raman A, Schaefer CW, Withers TM, editors. *Biology, ecology, and evolution of gall-inducing arthropods*. Enfield (NH): Science Publishers Inc. p. 143–158.
- Burckhardt D, Conci C, Lauterer P, Tamanini L. 1991. Taxonomy and biology of *Trioza tripteridis* on *Valeriana* spp. (Homoptera: Psylloidea). *Boll Soc Entomol Ital.* 122:165–172.
- Burckhardt D, Hanson P, Madrigal L. 2005. *Diclidophlebia lucens*, n. sp (Hemiptera: Psyllidae) from Costa Rica, a potential control agent of *Miconia calvescens* (Melastomataceae) in Hawaii. *Proc Entomol Soc Wash.* 107:741–749.
- Burckhardt D, Lauterer P. 1982. *Trioza laserpitii* sp.n., a new Central European psyllid (Homoptera, Psylloidea). *Reichenbachia* 20:145–153.
- Burckhardt D, Lauterer P. 1997. Systematics and biology of the *Aphalara exilis* (Weber and Mohr) species assemblage (Hemiptera: Psyllidae). *Entomol Scand.* 28:271–305.
- Burckhardt D, Lauterer P. 2002. Revision of the *Trioza rotundata* Flor complex (Hemiptera: Psylloidea): taxonomy and biology. *Mitt Schweizerischen Entomol Ges.* 75:21–34.
- Burckhardt D, Lauterer P. 2006. The palaeartic trioziids associated with Rubiaceae (Hemiptera, Psylloidea): a taxonomic re-evaluation of the *Trioza galii* Foerster complex. *Rev Suisse Zool.* 113:269–286.
- Burts EC. 1970. The pear psylla in central Washington. *Wash Agri Exp Stn Circ.* 516:1–13.
- Burts EC, Fischer WR. 1967. Mating behaviour, egg production and egg fertility in the pear psylla. *J Econ Entomol.* 60:1297–1300.
- Butignol CA, Pedrosa MJH. 2003. Biologia de *Neotrioza tavaresi* Crawford, 1925 (Hemiptera, Psyllidae), galhador da folha do aracazeiro (*Psidium cattleianum*). *Rev Brasil Entomol.* 47:1–7.
- Butt BA, Stuart C. 1986. Oviposition by summer and winter forms of pear psylla *Psylla pyricola* on dormant pear budwood. *Environ Entomol.* 15:1109–1110.
- Butt BA, Stuart LC, Bell RL. 1989. Feeding, longevity, and development of pear psylla (Homoptera, Psyllidae) nymphs on resistant and susceptible pear genotypes. *J Econ Entomol.* 82:458–461.
- Butterfield J, Whittaker JB, Fielding CA. 2001. Control of the flexible annual/biennial life cycle of the heather psyllid *Strophingia ericae*. *Physiol Entomol.* 26:266–274.
- Campbell KG. 1964. Sound production by Psyllidae (Hemiptera). *J Entomol Soc Aust.* 1:3–4.
- Campbell KG. 1992. The biology and population ecology of two species of *Cardiaspina* (Hemiptera: Psyllidae) in plague numbers on *Eucalyptus grandis* in New South Wales. *Proc Linn Soc NSW.* 113:135–150.
- Cannon RJC. 1983. Cold hardiness in the heather psyllid *Strophingia ericae* (Homoptera: Psylloidea). *Cryo Lett.* 4:113–118.
- Carraro L, Ferrini F, Labonne G, Ermacora P, Loi N. 2004. Seasonal infectivity of *Cacopsylla pruni*, vector of European stone fruit yellows phytoplasma. *Ann Appl Biol.* 144:191–195.
- Carraro L, Loi N, Ermacora P, Gregoris A, Osler R. 1998. Transmission of pear decline by using naturally infected *Cacopsylla pyri*. *Acta Horti.* 472:665–668.
- Carraro L, Osler R, Loi N, Ermacora P, Refatti E. 1998. Transmission of European stone fruit yellows phytoplasmas by *Cacopsylla pruni*. *J Plant Pathol.* 80:233–239.
- Carter MW. 1949. The *Pittosporum* chermid *Powellia vitreoradiata* Mask. *NZ J Sci Tech.* B 31:31–42.
- Carver M. 1987. Distinctive motory behavior in some adult psyllids (Homoptera, Psylloidea). *J Aust Entomol Soc.* 26:369–372.
- Casteel CL, Walling LL, Paine TD. 2007. Effect of Mi-1.2 gene in natal host plants on behavior and biology of the tomato psyllid *Bactericera cockerelli* (Šulc) (Hemiptera: Psyllidae). *J Entomol Sci.* 42:155–162.



- Catling HD. 1969a. The bionomics of the South African citrus psylla *Trioza erytreae* (Homoptera: Psyllidae) part 1. The influence of the flushing rhythm of citrus and factors which regulate flushing. J Entomol Soc South Afr. 32:191–208.
- Catling HD. 1969b. The bionomics of the South African citrus psylla *Trioza erytreae* (Homoptera: Psyllidae) part 3. The influence of extremes of weather on survival. J Entomol Soc South Afr. 32:273–290.
- Catling HD. 1970. Distribution of psyllid vectors of citrus greening disease, with notes on biology and bionomics of *Diaphorina citri*. FAO Plant Prot Bull. 18:8–15.
- Catling HD. 1971. The bionomics of the South African citrus psylla *Trioza erytreae* (Homoptera: Psyllidae) part 5. The influence of host plant quality. J Entomol Soc South Afr. 34:381–391.
- Catling HD, Annecke DP. 1968. The ecology of the citrus psylla in the Letaba district of Northern Transvaal. S Afr Citrus J. 410:1–7.
- Center TD, Pratt PD, Tipping PW, Rayamajhi MB, Van TK, Wineriter SA, Dray FA. 2007. Initial impacts and field validation of host range for *Boreioglycaspis melaleucae* Moore (Homoptera: Psyllidae), a biological control agent of the invasive tree *Melaleuca quinquenervia* (Cav.) Blake. Environ Entomol. 36:569–576.
- Center TD, Pratt PD, Tipping PW, Rayamajhi MB, Van TK, Wineriter SA, Dray FA, Purcell M. 2006. Field colonization, population growth, and dispersal of *Boreioglycaspis melaleucae* Moore, a biological control agent of the invasive tree *Melaleuca quinquenervia* (Cav.) Blake. Biol Control. 39:363–374.
- Chang JF, Philogene BJR. 1976. The development and behavior of the pear psylla *Psylla pyricola* (Homoptera Psyllidae) on different pear rootstocks and cultivars. Phytoprotection 57:137–149.
- Chang KP, Lee CS, Hsiao WF. 1995. Life cycle of Philippine ebony persimmon psyllid, *Trioza magnicauda* Crawford (Homoptera: Psyllidae) and insecticide screening of their control. Plant Prot Bull Taichung. 37:423–432.
- Chang K, Musgrave A. 1969. Histochemistry and ultrastructure of the mycetome and its “symbiotes” in the pear psylla, *Psylla pyricola* (Homoptera). Tissue Cell. 1:597–606.
- Chatterjee PH, Sebastian VO. 1965. Inhibition of inflorescence in *Mangifera indica* Linn. by the gall-forming psyllid *Apsylla cistellata* Buckt (Psyllidae- Homoptera). Control measures. Indian For. 91:228–230.
- Chazeau J. 1987. Le psylle du faux-mimosa en Asie du sud-est et dans la Pacifique: etat du probleme et perspectives de lutte (*Leucaena leucocephala* (Lam de Wit) – *Heteropsylla cubana* Crawford. Rev Elev Med Vet Nouv Caladonie. 9:23–27.
- Chen M, Miyakawa T, Matsui C. 1973. Citrus likubin pathogens in salivary glands of *Diaphorina citri*. Phytopathology 63:194–195.
- Cheng L, Birch MC. 1978. Insect flotsam: an unstudied marine resource. Ecol Entomol. 3:87–97.
- Chiara SR, Rapisarda C, Russo A, Zagami S. 1990. Alcuni fitofagi dell’otano napoletano in Calabria. Inf Fitopatol. 40:25–30.
- Chon DR. 1964. Experiment on the life history and the control of *Anomoneura mori* Schwarz (mulberry psyllid). Seric J Korea 4:33–39.
- Clark LR. 1962. The general biology of *Cardiaspina albitextura* (Psyllidae). Aust J Zool. 10:537–586.
- Clark LR. 1963a. Factors affecting the attractiveness of foliage for oviposition by *Cardiaspina albitextura* (Psyllidae). Aust J Zool. 11:20–34.
- Clark LR. 1963b. The influence of population density on the number of eggs laid by females of *Cardiaspina albitextura* (Psyllidae). Aust J Zool. 11:190–201.
- Clark LR, Dallwitz MJ. 1975. The life system of *Cardiaspina albitextura* (Psyllidae) 1950–1974. Aust J Zool. 23:523–561.

- Cobbinah JR. 1986. Factors affecting the distribution and abundance of *Phytolyma lata* (Homoptera, Psyllidae). *Insect Sci Appl.* 7:111–115.
- Cobbinah JR, Wagner MR. 1995. Phenotypic variation in *Milicia excelsa* to attack by *Phytolyma lata* (Psyllidae). *For Ecol Manag.* 75:147–153.
- Collett N. 2001. Biology and control of psyllids, and the possible causes for defoliation of *Eucalyptus camaldulensis* Dehnh. (red river gum) in south-eastern Australia – a review. *Aust For.* 64:88–95.
- Compere H. 1916. Notes on the tomato psylla. *Mon Bull Calif Comm Horti.* 5:189–191.
- Conci C. 2000. Iconography of eggs of Italian Psylloidea (Insecta: Homoptera). *Atti Accad Roveretana Degli Agiati (Ser VII)* 10B:5–32.
- Conci C, Tamanini L. 1982. *Psylla limbata*, nuova per l'Italia, da *Rhamnus alpinus* (Homoptera: Psylloidea). *Atti Soc Ital Sci Nat Mus Civic Stor Nat Milan.* 123:483–494.
- Conci C, Tamanini L. 1983. *Crastina (Eustigmatia) loginovae* n. sp. dell'Italia centrale, da *Tamarix gallica*, un genere nuova per l'Europa Centro-Occidentale. *Atti Soc Ital Sci Nat Mus Civic Storia Nat Milan.* 124:97–104.
- Conci C, Tamanini L. 1984a. *Floria (Floria) poggii* n.sp., from Sardinia, host plant *Genista corsica* (Homoptera: Psylloidea). *Ann Mus Civic Storia Nat Genova.* 85:43–49.
- Conci C, Tamanini L. 1984b. *Phylloplecta trisignata* (Low, 1986), host plant *Rubus* sp., of the complex *Rubi Corylifolii*. *Stud Trent Sci Nat, Acta Biol.* 61:249–261.
- Conci C, Tamanini L. 1984c. *Trioza (Hippophaetrioza* n. subgen.) *binotata* from Alto Adige, new for Italy (Homoptera: Psylloidea). *Stud Trent Sci Nat, Acta Biol.* 61:239–248.
- Conci C, Tamanini L. 1984d. *Trioza (Trioza) rapisardai* n.sp. from Piemonte, host plant *Laserpitium siler*. *Atti Soc Ital Sci Nat Mus Civic Storia Nat Milan.* 125:201–208.
- Conci C, Tamanini L. 1985a. *Arytainilla spartiicola* from Puglia, new for Italy (Homoptera: Psylloidea). *Atti Accad Roveretana Degli Agiati (Ser VI)* 25:123–136.
- Conci C, Tamanini L. 1985b. *Lauritrioza* n. gen. for *Trioza alacris* (Homoptera: Psylloidea). *Atti Soc Ital Sci Nat Mus Civic Storia Nat Milan.* 126:237–256.
- Conci C, Tamanini L. 1985c. Redescription of *Trioza ilicina* (De Stefani Perez, 1901) comb.n. from *Quercus ilex* (Homoptera: Psylloidea). *Boll Lab Entomol Agrar Filippo Silvestri, Portici.* 42:33–46.
- Conci C, Tamanini L. 1986a. *Cyamophila prohaskai* from Alto Adige and Trentino, genus and species new for Italy. *Stud Trent Sci Nat, Acta Biol.* 62:59–68.
- Conci C, Tamanini L. 1986b. The nymph of *Phylloplecta trisignata* (L ow) and new data on the morphology and the life history of the species (Homoptera: Psylloidea: Triozidae). *Boll Ist Entomol "Guido Grandi" Univ Bologna Lab Entomol Agrar Filippo Silvestri, Portici.* 41:93–100.
- Conci C, Tamanini L. 1986c. *Trioza saxifragae* in Trentino, new for Italy from *Saxifraga azoides* (Homoptera: Psylloidea). *Ann Mus Civici Rovereto* 2:159–168.
- Conci C, Tamanini L. 1987. Observations on *Trioza rotundata* Flor (Homoptera: Psylloidea). *Ann Mus Civici Rovereto* 3:265–284.
- Conci C, Tamanini L. 1988. Rare or interesting species of Italian Psylloidea 1 (Homoptera). *Atti Accad Roveretana Degli Agiati (Ser VI)* 28B:47–72.
- Conci C, Tamanini L. 1989a. *Cacopsylla iteophila* in Alto Adige and Trentino, new for Italy (Homoptera Psylloidea). *Ann Mus Civici Rovereto* 5:205–218.
- Conci C, Tamanini L. 1989b. Life history, nymphs and egg of *Cyamophila prohaskai*, host plant *Anthyllis vulneraria* ssp. *alpestris* (Homoptera: Psylloidea). *Stud Trent Sci Nat, Acta Biol.* 65:137–146.
- Conci C, Tamanini L. 1990. Notes on the genus *Psyllopsis* (Homoptera: Psylloidea). *Atti Accad Roveretana Degli Agiati (Ser VI)* 29B:57–85.
- Conci C, Tamanini L. 1991. Triozidae new or interesting for Italy (Homoptera: Psylloidea). *Atti Accad Roveretana Degli Agiati (Series VI)* 30B:37–60.

- Conci C, Rapisarda C, Tamanini L. 1993. Annotated catalogue of the Italian Psylloidea. First Part (Insecta: Homoptera). Atti Accad Roveretana Degli Agiati (Ser VII) 2B:33–136.
- Conci C, Rapisarda C, Tamanini L. 1996. Annotated catalogue of the Italian Psylloidea. Second part (Insecta: Homoptera). Atti Accad Roveretana Degli Agiati (Ser VII) 5B:5–207.
- Conconi RE de J. 1973. Biological observations on *Paurocephala tuxtlaensis* n.sp. (Homoptera: Psyllidae). Folia Entomol Mexican. 25–26:33–34.
- Costanzi M, Santana DLS, Terra AL, Penteado SR, Iede ET, Morey CS. 2003. Un nouveau psylle sur les eucalyptus de la Riviere Ligure et de la Côte d'Azur. Premieres observations de *Ctenarytaina spatulata* Taylor dans le Bassin Mediterranean Occidental. Phytoma – Defense Veg. 566:48–51.
- Cousin MT, Boudon-Padieu E. 2002. Phytoplasmes et phytoplasmoses: vecteurs, methodes de lutte et themes de recherche. Cahiers Agri 11:115–126.
- Crawford SA, Wilkens S. 1996. Ultrastructural aspects of damage to leaves of *Eucalyptus camaldulensis* by the psyllid *Cardiaspina retator*. Micron 27:359–366.
- Dabek AJ. 1983. *Wissadula* proliferation in Jamaica. Vol.2. Psyllid transmission and antibiotic therapy. Phytopathol Z. 107:345–361.
- Dahlsten DL, Kent DM, Rowney DL, Copper WA, Young TE, Tassan RL. 1995. Parasitoid shows potential for biocontrol of *Eugenia* psyllid. Calif Agri. 49:36–40.
- Danks HV. 2002. The range of insect dormancy responses. Eur J Entomol. 99:127–142.
- Danks HV. 2005. Key themes in the study of seasonal adaptation in insects I. Patterns of cold hardiness. Appl Entomol Zool. 40:199–211.
- Danks HV. 2006. Key themes in the study of seasonal adaptation in insects II. Life history patterns. Appl Entomol Zool. 41:1–13.
- Danks HV. 2007. The elements of seasonal adaptation in insects. Can Entomol. 139:1–44.
- Das AK, Rao CN, Singh S. 2007. Presence of citrus greening (Huanglongbing) disease and its psyllid vector in the North-Eastern region of India confirmed by PCR technique. Curr Sci. 92:1759–1763.
- Das PK, Singh RN, Brahmachari BN, Sharan SK, Sengupta K. 1988. Seasonal intensity of infestation of the gall insect *Trioza fletcheri minor* Crawford on *Terminalia tomentosa* and *Terminalia arjuna* and its control through systemic insecticides. Indian J Seric. 27:117–121.
- Daugherty MP, Briggs CJ, Welter SC. 2007. Bottom-up and top-down control of pear psylla (*Cacopsylla pyricola*): fertilization, plant quality, and the efficacy of the predator *Anthocoris nemoralis*. Biol Control. 43:257–264.
- Davatchi AG. 1958. Étude biologique de la faune entomologique des *Pistacia* sauvages et cultivés. Rev Pathologie Veg Entomol Agri Fr. 37:1–166.
- Davies DL, Guise CM, Clark MF, Adams AN. 1992. Parry's disease of pears is similar to pear decline and is associated with mycoplasma-type organisms transmitted by *Cacopsylla pyricola*. Plant Pathol. 41:195–203.
- Davis AC. 1937. Observations on the life history of *Paratrioza cockerelli* (Šulc) in southern California. J Econ Entomol. 30:377–379.
- Davis BNK. 1973. The Hemiptera and coleopterous fauna of stinging nettle in East Anglia. J Appl Ecol. 10:213–237.
- Davis RI, Gunua TG, Kame MF, Tenakanai D, Ruabete TK. 2005. Spread of citrus huanglongbing (greening disease) following incursion into Papua New Guinea. Aust Plant Pathol. 34:517–524.
- Del Bene G, Gargani E, Landi S. 1997. Observations on the life cycle and diapause of *Euphyllura olivina* (Costa) and *Euphyllura phillyreae* Foerster (Homoptera: Aphalaridae). Adv Horti Sci. 11:10–16.
- Delic D, Martini M, Ermacora P, Carraro L, Myrta A. 2005. First report of fruit tree phytoplasmas and their psyllid vectors in Bosnia and Herzegovina. J Plant Pathol. 87:150–150.

- De Meirleire H. 1971. Le Psylle du laurier sauce. *Phytoma* 226:38.
- Dempster JP. 1968. Intra-specific competition and dispersal as exemplified by a psyllid and its anthocorid predator. In: Southwood TRE, editor. *Insect abundance*. Oxford (UK): Blackwell Scientific Publications. p. 8–17.
- De Queiroz Santana DL, Burckhardt DH. 2001. A new trioqid pest (Homoptera, Psylloidea, Triozidae) on ornamental trumpet trees (*Tabebuia* spp., Bignoniaceae) in Brazil. *Rev Suisse Zool.* 108:541–550.
- Deronzier S. 1981. Bioécologie et dynamique des populations de *Psylla pyri* L. (Homoptera: Psyllidae) [doctoral thesis]. [Marseille (France)]: University of Marseille.
- Deronzier S. 1984. Dynamique des populations de *Psylla pyri* L. en verger abandonné dans le sud-est de France. *Agronomie* 4:549–556.
- Deronzier S, Atger P. 1980. Elements d'étude de la dynamique des populations de *Psylla pyri* L. dans la basse vallée du Rhône: periode hivernale et printaniere. *Acta Oecol.* 1:247–258.
- Dhiman SC, Singh S. 2003. Some ecological aspects of *Trioza hirsuta* Crawford (Homoptera: Psyllidae): A pest of *Terminalia tomentosa*. *J Exp Zool India.* 6:373–376.
- Dhiman SC, Singh S. 2004. Biology of *Trioza hirsuta* Crawford (Homoptera: Psyllidae), a pest of *Terminalia tomentosa* W & A. *Indian For* 130:680–690.
- Ding J, Du J, Zhang Y, Yu J, Wu G. 1987. Studies on *Thysogyna limbata* Enderlein (Homoptera: Psyllidae) in Nanjing. *J Nanjing Agri Univ.* 3:47–57.
- Domenichini G. 1967. La *Psylla melanoneura* Foerster (Homoptera) nel Nord Italia. *Boll Zool Agrar Bachic.* 8:169–180.
- Donnelly GP. 2002. The host range and biology of the mesquite psyllid *Heteropsylla texana*. *Biocontrol* 47:363–371.
- Douglas JW. 1878. The natural history of *Psylla succincta*. *Entomol Mon Mag.* 15:68–69.
- Downer JA, Avihra P, Molinar RH, Fraser JB, Koehler CS. 1988. New psyllid pest of California pepper tree. *Calif Agri.* 42:30–32.
- Downer JA, Koehler CS, Paine TD. 1991. Biology and management of the the eugenia psyllid *Trioza eugeniae* Froggatt. *J Environ Horti.* 9:137–141.
- Ellis PR, Hardman JA. 1992. Pests of umbelliferous crops. In: McKinlay RG, editor. *Vegetable crop pests*. Boca Raton (FL): CRC Press. p. 327–383.
- Entwistle PF. 1972. *Pest of Cocoa*. Bristol (UK): Longman.
- Espirito-Santo MM, Wilson Fernandez G. 1998. Abundance of *Neopelma baccharidis* (Homoptera: Psyllidae) galls on the dioecious shrub *Baccharis dracunculifolia* (Asteraceae). *Environ Entomol.* 27:870–876.
- Espirito-Santo MM, Wilson Fernandes GW. 2002. Host plant effects on the development and survivorship of the galling insect *Neopelma baccharidis* (Homoptera: Psyllidae). *Aust Ecol.* 27:249–257.
- Essig EO. 1917. Tomato and laurel psyllids. *J Econ Entomol.* 10:433–444.
- Eyer JR. 1937. Physiology of psyllid yellows of potatoes. *J Econ Entomol.* 30:891–898.
- Eyer JR, Crawford RF. 1933. Observations on the feeding habits of the potato psyllid (*Paratrioza cockerelli* Šulc) and the pathological history of the psyllid yellows which it produces. *J Econ Entomol.* 26:847–850.
- Felt EP. 1906. Bramble flea louse. *Mem NY State Mus.* 1:688–689.
- Ferreira SA, Wilson Fernandes G, Carvalho LG. 1990. Biology and natural history of *Euphaleurus ostreoides* (Homoptera: Psyllidae) a gall former on *Lonchocarpus guilleminiaus*. *Rev Brasil Biol.* 50:417–424.
- Ferris GF, Hyatt P. 1923. The life history of *Euphyllura arbuti* Schwarz (Homoptera: Chermidae). *Can Entomol.* 55:88–92.
- Fields GJ, Zwick RW. 1975. Elimination of ovarian diapause in pear psylla *Psylla pyricola* in the laboratory. *Ann Entomol Soc Am.* 68:1037–1038.

- Finlay-Doney M, Walter GH. 2005. Discrimination among host plants (*Leucaena* species and accessions) by the psyllid pest *Heteropsylla cubana* and implications for understanding resistance. *Agri For Entomol.* 7:153–160.
- Font I, Abad P, Albinana M, Espino AI, Dally EL, Davis RE, Jorda C. 1999. Amarillos y enrojecimiento en zanahoria: una enfermedad a diagnostico. *Boll Sanidad Veg Plagas* 25:405–415.
- Fox Wilson G. 1923. The eucalyptus psyllid *Eurhinocola eucalypti*. *Gardener's Chron.* 76:425.
- Frisinghelli C, Delaiti L, Grando MS, Forti D, Vindimian ME. 2000. *Cacopsylla costalis* (Flor 1861) as a vector of apple proliferation in Trentino. *J Phytopathol.* 148:425–431.
- Fukatsu T, Nikoh N. 1998. Two intracellular symbiotic bacteria from the mulberry psyllid *Anomoneura mori* (Insecta, Homoptera). *Appl Environ Microbiol.* 64:3599–3606.
- Fye RE. 1983. Dispersal and winter survival of the pear psylla. *J Econ Entomol.* 76:311–315.
- Gadug S, Hussein MY. 1987. The biology of the durian carsidarid *Tenaphalara malayensis* Crawford. *Pertanika* 10:243–246.
- Gegechkori AM. 1984. Psyllids (Homoptera: Psylloidea) of the Caucasus. Tbilisi (Georgia): *Academii Nauk Gruzinskoi SSR.*
- Gegechkori AM, Djibladzne DS. 1976. The psyllids of Colchida. Tbilisi (Georgia): Institut A.C. Pushkin.
- Gegechkori AM, Loginova MM. 1990. The psyllids (Homoptera: Psylloidea) of the USSR. Tbilisi (Georgia): *Academii Nauk Gruzinskoi SSR.*
- Geiger CA, Gutierrez AP. 2000. Ecology of *Heteropsylla cubana* (Homoptera: Psyllidae): psyllid damage, tree phenology, thermal relations, and parasitism in the field. *Environ Entomol.* 29:76–86.
- Gençer NS, Coskuncu KS, Kumral NA. 2007. The colonization preference and population trends of larval fig psylla, *Homotoma ficus* L. (Hemiptera: Homotomidae). *J Pest Sci.* 80:1–8.
- Giunchedi L, Pollini CP, Biondi S, Babini AR. 1994. PCR detection of MLOs in quick decline-affected pear trees in Italy. *Ann Appl Biol.* 124:399–403.
- Glick PA. 1939. The distribution of insects, spiders and mites in the air. *Technical Bull US Dep Agri.* 673:1–151.
- Green GC, Catling HD. 1971. Weather Induced mortality of the citrus psylla *Trioza erytreae* (Homoptera Psyllidae), a vector of greening virus in some citrus-producing areas of Southern African. *Agri Meteorol.* 8:305–317.
- Grove AJ, Gosh CC. 1914. The life history of *Psylla isitis* Buckt. (*Psyllopa punctipennis* Crawford). The “psylla” disease of indigo. *Mem Dep Agri in India (Entomol.)* 4:329–357.
- Hågvar EB, Hågvar S. 1975. Studies on the invertebrate fauna on branches of spruce *Picea abies* during winter. *Nor J Entomol.* 22:23–30.
- Halbert SE, Manjunath KL. 2004. Asian citrus psyllids (Sternorrhyncha: Psyllidae) and greening disease of citrus: A literature review and assessment of risk in Florida. *Fl Entomol.* 87:330–353.
- Hansen AK, Jeong G, Paine TD, Stouthamer R. 2007. Frequency of secondary symbiont infection in an invasive psyllid relates to parasitism pressure on a geographic scale in California. *Appl Environ Microbiol.* 73:7531–7535.
- Hansen LO, Hodkinson ID. 2006. The mistletoe associated psyllid *Cacopsylla visci* (Curtis, 1835) (Homoptera, Psyllidae) in Norway. *Nor J Entomol.* 53:89–91.
- Hardy AC, Cheng L. 1986. Studies in the distribution of insects by aerial currents. Vol. 3. Insect drift over the sea. *Ecol Entomol.* 11:283–290.
- Harisanov A. 1966a. Biological and ecological studies on the peach psyllid (*Psylla pruni* Scopoli). *Nauchni Trudove-Vissh Selskostopanski Institut Plovdiv* 15:249–259.
- Harisanov A. 1966b. Biological studies on the southern apple leaf hopper *Psylla costalis* Flor. *Nauchni Trudove-Vissh Selskostopanski Institut Plovdiv* 15:261–270.

- Harris MK. 1973. Host resistance to the pear psylla in a *Pyrus communis* × *P. ussuriensis* hybrid. *Environ Entomol.* 2:883–887.
- Heard SB, Buchanan CK. 1998. Larval performance and association within and between two species of hackberry nipple gall insects, *Pachypsylla* spp. (Homoptera: Psyllidae). *Am Midland Nat.* 140:351–357.
- Heeger E. 1856. Beitrage zur naturgeschichte der Insecten. Sitzung Akad Wiss Wien, Math Naturwiss. 18:33–47.
- Heinze K, Profft J. 1939. Uber Psylliden und Psyllidenschaden an der Kartoffel. *Arb Physiol Angew Entomol Berlin-Dahlen* 6:198–208.
- Heslop-Harrison G. 1937. Observations on the biology of certain British Psyllidae. *Entomologist* 70:1–4.
- Heslop-Harrison G. 1942. Notes on the genus *Psyllopsis* Loew (Hem., Psyllidae) with special reference to the British species found on *Fraxinus*. *Entomol Mon Mag.* 78:155–160.
- Heslop-Harrison G. 1949a. A new Indo-Malayan genus and species of the family Psyllidae (Hemiptera-Homoptera). *Entomol Mon Mag.* 85:161–164.
- Heslop-Harrison G. 1949b. The subfamily Liviinae Loew of the homopterous family Psyllidae II. *Ann Mag Nat Hist (12th ser.)* 2:241–270.
- Heslop-Harrison G. 1951. The Aryanini of the subfamily Psyllinae, Hemiptera-Homoptera, family Psyllidae. *Ann Mag Nat Hist (12th ser.)* 4:417–454.
- Heslop-Harrison G. 1961. Sound production in the Homoptera with special reference to the sound producing mechanisms in the Psyllidae. *Ann Mag Nat Hist.* 3:633–640.
- Hibino H, Kaloostian G, Schneider H. 1971. Mycoplasma-like bodies in the pear psylla vector of pear decline. *Virology* 43:34–40.
- Hildebrand M, Dickler E, Geider K. 2000. Occurrence of *Erwinia amylovora* on insects in a fire blight orchard. *J Phytopathol.* 148:251–256.
- Hill DS. 1982. Hong Kong insects. Vol. 2. Hong Kong: The Urban Council. p. 33–34.
- Hill JK, Hamer KC, Hodkinson ID. 1998. Variation in resource exploitation along an altitudinal gradient: the willow psyllids (*Cacopsylla* spp.) on *Salix lapponum*. *Ecography* 21:289–296.
- Hill JK, Hodkinson ID. 1995. Effects of temperature on phenological synchrony and altitudinal distribution of jumping plant lice (Hemiptera, Psylloidea) on dwarf willow (*Salix lapponum*) in Norway. *Ecol Entomol.* 20:237–244.
- Hill JK, Hodkinson ID. 1996. Effects of photoperiod and raised winter temperatures on egg development and timing of oviposition in the willow psyllid *Cacopsylla moscovita*. *Entomol Exp Appl.* 78:143–147.
- Hodgson CJ, Mustafa TM. 1984. The dispersal and flight activity of *Psylla pyricola* Foerster in southern England. Lutte intégré contre les psylles du poirier. *Bull OILB/SROP*, p. 330–353.
- Hodkinson ID. 1972. Long range dispersal of certain species of Psyllidae in the Northern Pennines. *Entomol Mon Mag.* 108:21–22.
- Hodkinson I. 1973a. Population dynamics and host plant interactions of *Strophingia ericae* (Curt.) (Homoptera: Psylloidea). *J Anim Ecol.* 42:565–583.
- Hodkinson ID. 1973b. The biology of *Strophingia ericae* (Homoptera Psylloidea) with notes on its primary parasite *Tetrastichus actis* (Hymenoptera Eulophidae). *Norsk Entomol Tidsskrift* 20:237–243.
- Hodkinson ID. 1974. The biology of the Psylloidea (Homoptera): a review. *Bull Entomol Res.* 64:325–338.
- Hodkinson ID. 1981. Status and taxonomy of the *Trioza nigricornis* complex (Hemiptera: Homoptera:Trioziidae). *Bull Entomol Res.* 71:671–680.
- Hodkinson ID. 1983a. Facultative parthenogenesis in *Psylla myrtilli* (Homoptera: Psyllidae): the saga continues in Norway. *Fauna Nor Ser B.* 30:1–2.

- Hodkinson ID. 1983b. The psyllids (Homoptera, Psylloidea) of the Austro-Oriental, Pacific and Hawaiian zoogeographical realms – an annotated check list. *J Nat Hist.* 17:341–377.
- Hodkinson ID. 1983c. Psyllids (Homoptera: Psylloidea) collected in yellow water trays in northern Italy. *Entomol Gaz.* 34:279–280.
- Hodkinson ID. 1984. The biology and ecology of the gall-forming Psylloidea. In: Ananthakrishnan R, editor. *The biology of gall forming insects.* London: Edward Arnold. p. 59–77.
- Hodkinson ID. 1986a. Co-evolution between psyllids (Homoptera: Psylloidea) and rain forest trees: the first 120 million years. In: Chadwick AC, Sutton S, editors. *Tropical rain forest: the Leeds symposium.* Leeds: Leeds Philosophical Society. p. 187–194.
- Hodkinson ID. 1986b. The psyllids (Homoptera: Psylloidea) of the Oriental zoogeographical region: an annotated checklist. *J Nat Hist.* 20:299–357.
- Hodkinson ID. 1988a. The hitchhiker's guide to foreign food. *New Sci.* 118(1611):47–51.
- Hodkinson ID. 1988b. The Nearctic Psylloidea (Insecta: Homoptera): an annotated check list. *J Nat Hist.* 22:1179–1244.
- Hodkinson ID. 1997. Progressive restriction of host plant exploitation along a climatic gradient: The willow psyllid *Cacopsylla groenlandica* in Greenland. *Ecol Entomol.* 22:47–54.
- Hodkinson ID. 1999. Biocontrol of eucalyptus psyllid *Ctenarytaina eucalypti* by the Australian parasitoid *Psyllaephagus pilosus*: a review of current programmes and their success. *Biocontrol News Inf.* 20:129N–134N.
- Hodkinson ID. 2007. A new introduced species of *Ctenarytaina* (Hemiptera: Psylloidea) damaging cultivated *Eucalyptus parvula* (= *parvifolia*) in Europe. *Dtsche Entomol Z.* 54:27–33.
- Hodkinson ID, Bird JM. 1998. Host-specific insect herbivores as sensors of climate change in arctic and Alpine environments. *Arctic Alpine Res.* 30:78–83.
- Hodkinson ID, Bird JM. 2000. Sedge and rush-feeding psyllids of the subfamily Liviinae (Insecta: Hemiptera: Psylloidea): a review. *Zool J Linn Soc.* 128:1–49.
- Hodkinson ID, Bird JM. 2006a. Facultative parthenogenesis in *Cacopsylla myrtilli* (Wagner) (Hemiptera: Psylloidea) in northern Sweden. *Entomol Tidskrift* 127:157–160.
- Hodkinson ID, Bird JM. 2006b. Flexible responses of insects to changing environmental temperature – early season development of *Craspedolepta* species on fireweed. *Global Change Biol.* 12:1308–1314.
- Hodkinson ID, Bird JM. In press. The jumping plant lice or psyllids (Homoptera: Psylloidea) of Greenland. In: Bocher J, editor. *The insects of Greenland.* Copenhagen (Denmark): Danish Polar Centre.
- Hodkinson ID, Bird JM, Hill JK, Baxter R. 2001. Host plant growth characteristics as determinants of abundance and phenology in jumping plant-lice on downy willow. *Ecol Entomol.* 26:376–387.
- Hodkinson ID, Bird JM, Miles JE, Bale JS, Lennon JJ. 1999. Climatic signals in the life histories of insects: the distribution and abundance of heather psyllids (*Strophingia* spp.) in the UK. *Funct Ecol.* 13:83–95.
- Hodkinson ID, Casson D. 2000. Patterns within patterns: abundance-size relationships within the Hemiptera of tropical rain forest or why phylogeny matters. *Oikos* 88:509–514.
- Hodkinson ID, Jensen TS, Maclean SFJ. 1979. The distribution, abundance and host plant relationships of *Salix* feeding psyllids (Homoptera: Psylloidea) in Arctic Alaska. *Ecol Entomol.* 4:119–132.
- Hodkinson ID, White IM. 1981. The Neotropical Psylloidea (Homoptera, Insecta) – an annotated check list. *J Nat Hist.* 15:491–523.
- Hoffmann JH, Moran VC, Webb JW. 1975. Influence of host plant and saturation deficit on temperature tolerance of a psyllid (Homoptera). *Entomol Exp Appl.* 18:55–67.

- Hollis D. 2004. Australian Psylloidea. Jumping plant lice and lerp insects. Canberra (Australia): Australian Government, Australian Biological Resource Study.
- Horton DR. 1990a. Distribution and survival of eggs of summer form pear psylla (Homoptera: Psyllidae) affected by leaf mid-vein. *Environ Entomol.* 19:656–661.
- Horton DR. 1990b. Oviposition by overwintering morph of pear psylla (Homoptera, Psyllidae) with information on conditioning. *Environ Entomol.* 19:357–361.
- Horton DR, Broers DA, Hinojosa T, Lewis TM. 1998. Ovarian development in overwintering pear psylla, *Cacopsylla pyricola* (Homoptera: Psyllidae): seasonality and effects of photoperiod. *Can Entomol.* 130:859–867.
- Horton DR, Burts EC, Unruh TR, Krysan JL, Coop LB, Croft BA. 1994. Phenology of fall dispersal by winterform pear psylla (Homoptera, Psyllidae) in relation to leaf fall and weather. *Can Entomol.* 126:111–120.
- Horton DR, Guedot C, Landolt PJ. 2007. Diapause status of females affects attraction of male pear psylla, *Cacopsylla pyricola*, to volatiles from female-infested pear shoots. *Entomol Exp Appl* 123:185–192.
- Horton DR, Higbee BS, Krysan JL. 1994. Postdiapause development and mating status of pear psylla (Homoptera, Psyllidae) affected by pear and nonhost species. *Ann Entomol Soc Am.* 87:241–249.
- Horton DR, Krysan JL. 1990. Probing and oviposition-related activity of summerform pear psylla (Homoptera, Psyllidae) on host and nonhost substrates. *Environ Entomol.* 19:1463–1468.
- Horton DR, Krysan JL. 1991. Host acceptance behavior of pear psylla (Homoptera: Psyllidae) affected by plant species, host deprivation, habituation and egg load. *Ann Entomol Soc Am.* 84:612–627.
- Horton DR, Landolt PJ. 2007. Attraction of male pear psylla, *Cacopsylla pyricola*, to female-infested pear shoots. *Entomol Exp Appl.* 123:177–183.
- Horton DR, Lewis TM. 1996. Tethered flight activity of pear psylla, *Cacopsylla pyricola*: seasonal, host and morphotypic effects. *Entomol Exp Appl.* 78:39–49.
- Horton DR, Lewis TM, Neven LG. 1996. Reduced cold-hardiness of pear psylla (Homoptera: Psyllidae) caused by exposure to external water and surfactants. *Can Entomol.* 128:825–830.
- Hsieh FK, Chen S. 1977. Morphology and bionomics of the Taiwan mulberry psyllid *Paurocephala psylloptera* Crawford. *Plant Prot Bull.* 19:37–46.
- Human NB, Bedford ECG. 1985. Relationship between meteorological factors and the incidence of citrus psylla *Trioza erytreae* (Del Guercio) at Rustenburg from 1978 until 1982. *Subtropica* 6:19–23.
- Hung T-H, Hung S-C, Chen C-N, Hsu M-H, Su H-J. 2004. Detection by PCR of *Candidatus Liberibacter asiaticus*, the bacterium causing citrus huanglongbing in vector psyllids: application to the study of vector–pathogen relationships. *Plant Pathol.* 53:96–102.
- Hussain MA, Nath D. 1927. The citrus psylla (*Diaphorina citri* Kuw.) (Psyllidae: Homoptera). *Mem Dep Agri India* 10:5–27.
- Igboekwe AD. 1983. Studies on the damage to young cocoa seedlings by the cocoa psyllid *Tyora tessmanni* (Aulmann) (Homoptera, Psyllidae). *Café Cacao Thé* 27:67–70.
- Igboekwe AD, Adenuga AO. 1983. Studies on the bionomics of cocoa psyllid *Tyora tessmanni* (Aulmann) (Homoptera: Psyllidae). *Rev Zool Afr.* 97:896–904.
- Iglesias CA. 1983. Incidencia de la fenología foliar de *Tetragastris panamensis* en la distribución de *Calophya* sp. (Homoptera: Psyllidae). *Conciencia* 10:28–30.
- Jackson CS, Hodkinson ID, Stanley P. 1990. Cold-hardiness in the hawthorn psyllid *Cacopsylla melanoneura* (Foerster) (Homoptera: Psylloidea). *Entomologist* 109:224–230.
- Janes MJ, Davis AC. 1937. Observations on the life history of *Paratrioza cockerelli* in California. *J Econ Entomol.* 30:377–378.



- Jarausch B, Schwind N, Jarausch W, Krczal G, Dickler E, Seemuller E. 2003. First report of *Cacopsylla picta* as a vector of apple proliferation phytoplasma in Germany. *Plant Dis.* 87:101.
- Jarausch W, Danet JL, Labonne G, Dosba F, Broquaire JM, Saillard C, Garnier M. 2001. Mapping the spread of apricot chlorotic leaf roll (ACLR) in southern France and implication of *Cacopsylla pruni* as a vector of European stone fruit yellows (ESFY) phytoplasmas. *Plant Pathol.* 50:782–790.
- Jensen DD, Griggs WH, Gonzales CQ, Schneider H. 1964. Pear decline virus transmission by pear psylla. *Phytopathology* 54:1346–1351.
- Jonsson N. 1983. The life history of *Psylla mali* (Homoptera, Psyllidae) and its relationship to the development of the apple blossom. *Fauna Nor Ser B.* 30:3–8.
- Journet ARP. 1984. Associations of *Craspedolepta* species (Homoptera: Psylloidea) with goldenrod (*Solidago* spp.) in Quebec, Canada. *Rev Entomol Quebec.* 29:22–26.
- Junior M, Barros R, da Silva FR, de Vasconcelos GJN. 2005. Occurrence and biological aspects of the Clitoria tree psyllid in Brazil. *Sci Agricol.* 62:281–285.
- Kandasamy C. 1980. A new leaf gall by *Trioza gigantea* Craw. (Homoptera, Psyllidae) on *Vaccinium neilgherrense* (Vacciniaceae). *Curr Sci.* 49:754–754.
- Kandasamy C, Krishnan BH. 1981. First record of leaf galls on *Litsea stocksii* (Meissn) Hook F (Lauraceae) caused by a psyllid. *Curr Sci.* 50:967–968.
- Kapatos ET, Stratopoulou ET. 1996. Demographic study of the reproductive potential of pear psylla, *Cacopsylla pyri*. *Entomol Exp Appl.* 80:497–502.
- Kapatos ET, Stratopoulou ET. 1999. Duration times of the immature stages of *Cacopsylla pyri* L. (Hom., Psyllidae), estimated under field conditions, and their relationship to ambient temperature. *J Appl Entomol.* 123:555–559.
- Kaufmann T. 1973. Biology and ecology of *Tyora tessmanni* (Homoptera: Psyllidae) with special reference to its role as cocoa pollinator in Ghana. *J Kansas Entomol Soc.* 46:285–293.
- Klimaszewski SM. 1973. The jumping plant lice or psyllids (Homoptera: Psylloidea) of the Palearctic: an annotated checklist. *Ann Zool Warsaw.* 30:155–286.
- Knowlton GF. 1933. Note on host plants of *Paratrioza cockerelli*. *J Econ Entomol.* 26:730.
- Knowlton GF, Janes MJ. 1931. Studies on the biology of *Paratrioza cockerelli* (Šulc). *Ann Entomol Soc Am.* 24:283–291.
- Knowlton GF, Thomas WL. 1934. Host plants of the potato psyllid. *J Econ Entomol.* 27:547.
- Koehler CS, Kattoulas ME, Frankie GW. 1966. Biology of *Psylla uncatoides*. *J Econ Entomol.* 59:1097–1100.
- Konovalova ZA. 1963. On the biology of *Calophya nigra* Kuw. *Trudy Akad Nauk Sootsza SSR, Vladivostok* 17:91–95.
- Konovalova ZA. 1976. Leafhoppers (Homoptera, Psylloidea) in Primorsky Kray. *Trudy Biol-pochvennogo Inst (New Ser.)* 43:3–5.
- Krawczyk A, Migula P. 1979. Metabolism in Psylloidea. *Acta Physiol Polonica.* 30:114.
- Kristoffersen L, Anderbrant O. 2007. Carrot psyllid (*Trioza apicalis*) winter habitats – insights in shelter plant preference and migratory capacity. *J Appl Entomol.* 131:174–178.
- Krysan JL. 1990. Laboratory study of mating behavior as related to diapause in overwintering *Cacopsylla pyricola* (Homoptera, Psyllidae). *Environ Entomol.* 19:551–557.
- Krysan JL, Higbee BS. 1990. Seasonality of mating and ovarian development in overwintering *Cacopsylla pyricola* (Homoptera, Psyllidae). *Environ Entomol.* 19:544–550.
- Kudler J. 1968. *Diclidophlebia eastopi* (Vondracek) a psyllid harmful to *Triplochiton scleroxylon* (K Schum). *Technical Newsletter, Forest Products Research Institute, Ghana,* 11–14.
- Kumar SU, Raman A, Kader MSA. 1981. Physiological alterations in the leaves of *Buchanania lanzan* due to psyllid galls. *Curr Sci.* 50:963–964.

- Kuwayama S. 1971. Observations on the biology of the mulberry sucker. *Jpn J Appl Entomol Zool.* 15:115–120.
- Labonne G, Lichou J. 2004. Data on the life cycle of *Cacopsylla pruni* vector of European stone fruit yellows (ESFY) phytoplasma, in France. In: Llacer G, editor. Proceedings of the XIXth international symposium on virus and virus-like diseases of temperate fruit crops: fruit tree diseases. Leuven (Belgium): International Society for Horticultural Science. p. 465–470.
- Lahiri AR, Biswas S. 1980. Observations on the relative intensity of infection on three species of cultivated citrus plants by *Psylla murrayi* Mathur (Homoptera: Psyllidae) at Shillong, Meeghalaya. *Bull Zool Surv India.* 2:123–127.
- Lakra RK, Singh Z, Kharub WS. 1983. Population dynamics of citrus psylla *Diaphorina citri* Kuwayama in Haryana. *Indian J Entomol.* 45:301–310.
- Lal KB. 1934. The biology of the Scottish Psyllidae. *Trans R Entomol Soc Lond.* 82:363–385.
- Lapis EB, Borden JH. 1993a. Components of resistance of *Leucaena collinsii* (Leguminosae) to *Heteropsylla cubana* (Homoptera: Psyllidae). *Environ Entomol.* 22:319–325.
- Lapis EB, Borden JH. 1993b. Olfactory discrimination by *Heteropsylla cubana* (Homoptera: Psyllidae) between susceptible and resistant species of *Leucaena* (Leguminosae). *J Chem Ecol.* 19:83–90.
- Laska P. 1964. Zusammenfassung: Beitrag zu Bionomie und Bekämpfung der *Trioza apicalis* Forst. (Triozidae, Homoptera). *Zool Listy.* 13:327–332.
- Laska P. 1974. Study of *Trioza apicalis* (Triozidae: Homoptera). *Prirodoved Prace Ustavu Ceskoslovenske Akad Ved v Brne* 8:1–44.
- Laurema S. 1989. Free amino acids in the psyllid *Trioza apicalis* (Homopt., Triozidae) and in carrot leaves. *Ann Agri Fenn.* 28:113–120.
- Lauterer P. 1963. A contribution to the knowledge of the psyllid fauna of Czechoslovakia. *Cas Morav Mus, Brne.* 48:145–156.
- Lauterer P. 1965. A contribution to the knowledge of the psyllid fauna of Czechoslovakia II. *Cas Morav Mus, Brne.* 50:171–190.
- Lauterer P. 1976. Psyllids of wetland nature reserves of the German Democratic Republic with notes on their biology, taxonomy and zoogeography. *Faun Abh Dresden.* 6:111–122.
- Lauterer P. 1979. New and interesting records of psyllids from Czechoslovakia (Homoptera: Psylloidea). *Cas Morav Mus, Brne.* 64:93–102.
- Lauterer P. 1982. New data on the occurrence, bionomics and taxonomy of some Czechoslovakian Psylloidea (Homoptera). *Cas Morav Mus, Brne.* 67:133–162.
- Lauterer P. 1991. Psyllids (Homoptera: Psylloidea) of the limestone cliff zone of the Pavlovske Vrchy Hills (Czechoslovakia). *Cas Morav Mus, Brne.* 76:241–263.
- Lauterer P. 1993a. Notes on the bionomics and occurrence of some psyllids (Homoptera: Psylloidea) in Czechoslovakia and the Balkan Peninsula. *Cas Morav Mus, Brne.* 77(1992):147–156.
- Lauterer P. 1993b. Psyllids (Homoptera: Psylloidea) from the area flooded by the Nove Milyny reservoir system and its environs in southern Moravia. *Cas Morav Mus, Brne.* 78:165–200.
- Lauterer P. 1993c. Three faunistic novelties from the order Homoptera in the Czech and Slovak Republics (Auchenorrhyncha and Psylloidea). *Cas Morav Mus, Brne.* 78:213–214.
- Lauterer P. 1998. Results of the investigations on Hemiptera in Moravia, made by the Moravian Museum. *Cas Morav Mus, Brne.* 83:99–126.
- Lauterer P. 1999. Results of the investigations on Hemiptera in Moravia, made by the Moravian Museum (Psylloidea 2). *Cas Morav Mus, Brne.* 84:71–151.
- Lauterer P, Baudys E. 1968. Description of a new gall on *Chamaenerion angustifolium* (L.) Scop. produced by the larva of *Craspedolepta subpunctata* (Foer.) with notes on the bionomics of this psyllid. *Cas Morav Mus, Brne.* 53:243–248.

- Lauterer P, Broumas T, Drosopoulos S, Souliotis C, Tsourgianni A. 1998. Species of the genus *Agonoscena* (Homoptera, Psyllidae), pests on *Pistacia* and first record of *A. pistaciae* in Greece. *Ann Inst Phytophathol Benaki*. 18:123–128.
- Lauterer P, Burckhardt D. 2004. The west palaeartic species of the *Craspedolepta flavipennis* (Foerster) complex (Hemiptera: Psylloidea). *Mitt Schweiz Entomol Ges.* 77:251–275.
- Lauterer P, Janicek R. 1990. *Trioza neglecta* Loginova, a new species for the fauna of Hungary and Bulgaria (Homoptera: Psylloidea). *Folia Entomol Hung.* 51:163–165.
- Lauterer P, Prophetou DA, Tzanakakis ME. 1986. Occurrence of *Euphyllura phillyreae* Foerster (Homoptera: Aphalaridae) on olives of the Greek mainland. *Ann Entomol Soc Am.* 79:7–10.
- Lazarev MA. 1972. The Crimean apple sucker *Psylla melanoneura taurica* new-form (Homoptera: Psylloidea). *Entomol Obozr.* 51:23–26.
- Lazarev MA. 1975. New data on the biology of the pear sucker *Psylla pyrisuga* (Homoptera: Psylloidea) in the Crimea. *Entomol Obozr.* 54:758–759.
- Lazarev MA. 1979. New data on the biology of the common pear psylla *Psylla pyri* (Homoptera, Psyllidae) in the Crimea. *Entomol Obozr.* 58:53–56.
- Léclant F, Marchoux G, Giannotti J. 1974. Mise en évidence du rôle vecteur du psylle *Trioza nigricornis* Forst (Insecte, Homoptère) dans la transmission d'une maladie a prolifération de *Daucus carota* L. *Comptes Rendus Acad Sci, Paris Ser D.* 278:57–59.
- Ledoux A. 1955. Observations sur la biologie de *Phytolyma lata* Scott variété fusca, Psylloidea, gallicole sur l'Iroko (*Clorophora excelsa*). *Ann Sci Nat, Zool* (11th Ser.). 291–310.
- Lee RE, Litzgus JD, Mugnano JA, Lee MR, Horton DR, Dunley J. 1999. Evaluation of ice-nucleating microorganisms for reducing the supercooling capacity and cold-hardiness of *Cacopsylla pyricola* (Hemiptera: Psyllidae). *Can Entomol.* 131:715–723.
- Leege LM. 2006. The relationship between psyllid leaf galls and redbay (*Persea borbonia*) fitness traits in sun and shade. *Plant Ecol.* 184:203–212.
- Leeper JR, Beardsley JWJ. 1976. The biological control of *Psylla uncatoides* (Homoptera: Psyllidae) on Hawaii. *Proc Hawaiian Entomol Soc.* 22:307–321.
- Lehrman RS. 1930. Some observations on the life history of the tomato psyllid (*Paratrioza cockerelli* Šulc) (Homoptera). *J NY Entomol Soc.* 38:307–312.
- Leite MSP, Zanol KMR. 2001. Biologia e morfologia de *Gyropsylla spegazziniana* (Lizer y Trelles) (Hemiptera, Psyllidae). *Acta Biol Parana.* 30:19–34.
- List GM. 1939a. The effect of temperature upon egg deposition, egg hatch and nymphal development of *Paratrioza cockerelli* (Šulc). *J Econ Entomol.* 32:30–36.
- List GM. 1939b. The potato and tomato psyllid and its control on tomato. *Bull Colo Agri Exp Stn.* 454:1–33.
- Liu D, Johnson L, Trumble JT. 2006. Differential responses to feeding by the tomato/potato psyllid between two tomato cultivars and their implications in establishment of injury levels and potential of damaged plant recovery. *Insect Sci.* 13:195–204.
- Liu D, Trumble JT. 2004. Tomato psyllid behavioral responses to tomato plant lines and interactions of plant lines with insecticides. *J Econ Entomol.* 97:1078–1085.
- Liu D, Trumble JT. 2005. Interactions of plant resistance and insecticides on the development and survival of *Bactericera cockerelli* (Šulc) (Homoptera: Psyllidae). *Crop Prot.* 24:111–117.
- Liu D, Trumble JT. 2006. Ovipositional preferences, damage thresholds, and detection of the tomato-potato psyllid *Bactericera cockerelli* (Homoptera: Psyllidae) on selected tomato accessions. *Bull Entomol Res.* 96:197–204.
- Liu D, Trumble JT. 2007. Comparative fitness of invasive and native populations of the potato psyllid (*Bactericera cockerelli*). *Entomol Exp Appl.* 123:35–42.
- Liu HS, Chen CC, Lin CP. 2007. Detection and identification of the phytoplasma associated with pear decline in Taiwan. *European J Plant Pathol.* 117:281–291.

- Liu YH, Tsai JH. 2000. Effects of temperature on biology and life table parameters of the Asian citrus psyllid, *Diaphorina citri* Kuwayama (Homoptera: Psyllidae). *Ann Appl Biol.* 137:201–206.
- Lizer C. 1918. Sobre la presencia en Argentina de un psilido exotico (*Trioza alacris* F.). *Ann Zool Apl.* 5:16–21.
- Loginova MM. 1954. On the biology of leafhoppers of the genus *Psyllopsis* Löw in the Stalingrad region. *Trudy Zool Inst Acad Nauk SSR, Leningrad.* 38:88–104.
- Loginova MM. 1968. New data on the fauna and biology of the Caucasian Psylloidea (Homoptera). *Trudy Vses Entomol Obschestva.* 52:275–328.
- Loginova MM. 1970. New psyllids (Homoptera: Psylloidea) from Soviet Central Asia. *Entomol Obozr.* 49:370–385.
- Loginova MM. 1976. Psyllids of the Tribe Pachypsyllidini. *Zool Zhurnal.* 55:612–614.
- Loginova MM. 1982. Structure and morpho-ecological types of the psyllid nymphs (Homoptera: Psylloidea). *Trudy Zool Inst Acad Nauk SSR, Leningrad.* 105:20–52.
- Loginova MM, Parfentiev VJ. 1958. Leafhoppers (Homoptera: Psylloidea) injurious to *Populus diversifolia* and *P.prunosa* in the vicinity of Lake Bakhsh, Kazakhstan. *Entomol Obozr.* 38:88–104.
- Louda SM, Rodman JE. 1983. Ecological patterns in the glucosinolate content of a native mustard, *Cardamine cordifolia*, in the Rocky Mountains. *J Chem Ecol.* 9:397–422.
- Loureiro Ferreira J. 1946. Algumas observacoes biologicas e biometricas efectuadas em *Euphyllura olivina* Costa. *Agron Lusit, Lisbon.* 7:63–95.
- Löw F. 1877. Zur Biologie un Charakteristik der Psylloden nebst Beschreibung. *Verh Zool-Bot Ges Wien.* 26:187–216.
- Löw F. 1880. Mitteilungen uber Psylloden. *Verh Zool-Bot Ges Wien.* 29:549–598.
- Luft PA, Paine TD. 1997. Behavioral cues associated with oviposition by *Trioza eugeniae*. *Entomol Exp Appl.* 84:293–299.
- Luft PA, Paine TD. 1998. Potential biotic factors influencing settling of *Trioza eugeniae* nymphs (Homoptera: Triozidae) on young foliage. *Environ Entomol.* 27:1425–1430.
- Luft PA, Paine TD, Redak RA. 2001. Limiting the potential for intraspecific competition: regulation of *Trioza eugeniae* oviposition on unexpanded leaf tissue. *Ecol Entomol.* 26:395–403.
- Lundblad O. 1929. Morotbladloppan *Trioza viridula* Zett. dess biologi och upptradande som skadedjur i Sverige. *Medd Cent Lantsbruksentomologiska Avd.* 350(55):1–45.
- Lyoussoufi A, Armand E, Rieux RDAFF. 1992. Population dynamics of pear psylla *Psylla pyri* (L.) (Homoptera: Psyllidae) and beneficials in a sprayed orchard of south-eastern France. *Acta Phytopathol Entomol Hung.* 27:413–417.
- Lyoussoufi A, Gadenne C, Rieux R, Faivredarcier F. 1994. Diapause development of the pear psylla, *Cacopsylla pyri* (L.) under natural conditions. *Entomol Exp Appl.* 70:193–199.
- Lyoussoufi A, Rieux R, Faivre d’Arcier F. 1988. Evolution du potentiel de ponte et de l’effectif des oeufs du pyle du poirier *Psylla pyri* (L.) au cours de la periode hivernale et printaniere dans la basse vallée du Rhône. *J Appl Entomol.* 106:97–107.
- MacLean SF. 1983. Life cycles and the distribution of psyllids (Homoptera) in arctic and subarctic Alaska. *Oikos* 40:445–551.
- MacLean SF, Hodkinson ID. 1980. Distribution of psyllids (Homoptera: Psylloidea) in Arctic and subarctic Alaska. *Arctic Alpine Res.* 12:369–376.
- Madubunyi LC. 1967. Ecological investigations on the albizzia psyllid *Psylla uncatoides* (Ferris and Klyver)(Homoptera: Psylloidea) [masters thesis]. [Berkeley (CA)]: University of California.
- Madubunyi LC, Koehler CS. 1974. Development, survival and capacity for increase of albizzia psyllid at various constant temperatures. *Environ Entomol.* 3:1013–1016.
- Malenovsky I. 1999. Contribution a la faunistique des psylles d’Alsace (Hemiptera: Psylloidea). *Bull Soc Entomol Mulhouse.*, (April–June):17–34.

- Mally CW. 1894. Psyllidae found at Ames, Iowa. Proc Iowa Acad Sci. 2:152–171.
- Malausa JC, Giradet N. 1997. Lutte biologique contre le psylle de l'eucalyptus. Phytoma – Defense Veg. 498:49–51.
- Mangat BS. 1966. Biology and control of citrus psylla *Diaphorina citri* Kuw. Plant Prot Bull, N Delhi. 18:18–20.
- Mani MS. 1948. Cecidozoa and zooecidia from India. J R Asiatic Soc Bengal. 14:27–195.
- Mani T, Raman A. 1994. Biochemical changes in relation to growth in two leaf gall systems induced by *Trioza jambolanae* and *Microceropsylla longispiculata* (Homoptera: Psylloidea). Phytophaga 6:59–64.
- Mansilla JP, Pérez R, Del Estal P, Blond A. 2004. Detección en España de *Ctenarytaina spatulata* Taylor sobre *Eucalyptus globulus* Labill. Bol Sanid Veg, Plagas. 30:57–63.
- Markkula M, Laurema S. 1971. Phytotoxemia caused by *Trioza apicalis* (Homoptera, Triozidae) on carrot. Ann Agri Fenn. 10:181–184.
- Mathur RN. 1935. On the biology of the Psyllidae (Homopt.). Indian For Rec (New Ser.) 1:35–71.
- Mathur RN. 1946. On the immature stages of some Psyllidae. Indian J Entomol. 8:224–236.
- Mathur RN. 1975. Psyllidae of the Indian Subcontinent. New Delhi (India): Indian Council of Agricultural Research.
- Maxwell-Lefroy H. 1913. The *Psylla* disease of indigo in Behar. Agri J India. 8:1–26.
- McAtee WL. 1915. Psyllidae wintering on conifers about Washington DC. Science 41:940.
- McLean IFG. 1993. The host plant association and life history of *Trichohermes walkeri* (Forster) (Psylloidea: Triozidae). B J Entomol Nat Hist. 6:13–16.
- McLean IFG. 1994. The population dynamics of a gall forming psyllid. In: Leather SR, Watt AD, Mills NJ, Walters KFA, editors. Individuals, populations and patterns in ecology. Andover (UK): Intercept. p. 97–107.
- McLean IFG. 1998. The population ecology of *Trichohermes walkeri*. In: Dempster JP, McLean IFG, editors. Insect populations in theory and practice. London: Kluwer Academic Publishers. p. 341–366.
- McMullen RD, Jong C. 1972. Influence of temperature and host vigor on fecundity of the pear psylla (Homoptera, Psyllidae). Can Entomol. 104:1209–1212.
- McMullen RD, Jong C. 1976. Factors affecting induction and termination of diapause in pear psylla (Homoptera, Psyllidae). Can Entomol. 108:1001–1006.
- McMullen RD, Jong C. 1977. Effect of temperature on developmental rate and fecundity of the pear psylla *Psylla pyricola* (Homoptera, Psyllidae). Can Entomol. 109:165–170.
- Mead FW. 1963. A psyllid, *Trioza magnoliae* (Ashmead) (Homoptera: Psyllidae). Fl Dep Agri, Div Plant Ind, Entomol Circ. 15:1–2.
- Mead FW. 1966a. The blackberry psyllid *Trioza tripunctata* (Fitch). Fl Dep Agri, Div Plant Ind, Entomol Circ. 52:1–2.
- Mead FW. 1966b. Persimmon psyllid *Trioza diospyri* (Ashmead) (Homoptera: Psyllidae). Fl Dep Agri, Div Plant Ind, Entomol Circ. 50:1–2.
- Mead FW. 1967. A nest-making psyllid *Euphalerus nidifex* in Florida. Homoptera: Psyllidae Fl Dep Agri, Div Plant Ind, Entomol Circ. 67:1–2.
- Mead FW. 1977. The Asiatic citrus psylla *Diaphorina citri* Kuwayama (Homoptera: Psyllidae). Fl Dep Agri, Div Plant Ind, Entomol Circ. 180:1–4.
- Mead FW. 1983. Yaupon psyllid *Gyropsylla ilicis* (Ashmead) (Homoptera: Psyllidae). Fl Dep Agri, Div Plant Ind, Entomol Circ. 247:1–2.
- Mead FW. 1994. Eugenia psyllid, *Trioza eugeniae* Froggatt (Homoptera: Psyllidae). Fl Dep Agri, Div Plant Ind, Entomol Circ. 367:1–3.
- Mehrnejad MR. 1998. Evaluation of the parasitoid *Psyllaephagus pistaciae* (Hymenoptera: Ecyrtidae) as a biocontrol agent of the common pistacio psylla *Agonoscena pistaciae* (Homoptera: Psylloidea) [doctoral thesis]. [London (UK)]: University of London. 271.

- Mehrnejad MR. 2002. Bionomics of the common pistachio psylla, *Agonoscena pistaciae*, in Iran. In: Batlle I, Hormaza I, Espiau MT, editors. Proceedings of the 3rd International Symposium on Pistachios and Almond. Leuven (Belgium): International Society Horticultural Science. p. 535–539.
- Mehrnejad MR, Copland MJW. 2005. The seasonal forms and reproductive potential of the common pistachio psylla, *Agonoscena pistaciae* (Hem., Psylloidea). *J Appl Entomol.* 129:342–346.
- Mehrnejad MR, Copland MJW. 2006a. Host-stage selection and oviposition behaviour of *Psyllaephagus pistaciae*, parasitoid of the common pistachio psylla *Agonoscena pistaciae*. *Biol Control.* 36:139–146.
- Mehrnejad MR, Copland MJW. 2006b. Biological parameters of parasitoid *Psyllaephagus pistaciae* and its host *Agonoscena pistaciae* in relation to temperature. *J Entomol Res Soc.* 8:1–20.
- Mensah RK, Madden JL. 1991. Resistance and susceptibility of *Boronia megastigma* cultivars to infestations by the psyllid *Ctenarytaina thysanura*. *Entomol Exp Appl.* 61:189–198.
- Mensah RK, Madden JL. 1992a. Factors affecting *Ctenarytaina thysanura* oviposition on *Boronia megastigma* terminal shoots. *Entomol Exp Appl.* 62:261–268.
- Mensah RK, Madden JL. 1992b. Feeding behaviour and pest status of *Ctenarytaina thysanura* Ferris and Klyver (Hemiptera: Psyllidae) on *Boronia megastigma* Nees in Tasmania. *J Aust Entomol Soc.* 31:71–78.
- Mensah RK, Madden JL. 1993a. Development and application of an integrated pest management programme for the psyllid, *Ctenarytaina thysanura* on *Boronia megastigma* in Tasmania. *Entomol Exp Appl.* 66:59–74.
- Mensah RK, Madden JL. 1993b. Life history and biology of *Ctenarytaina thysanura* Ferris and Klyver (Hemiptera: Psyllidae) on *Boronia megastigma* Nees ex Bartl. (Rutaceae) in Tasmania. *J Aust Entomol Soc.* 32:327–337.
- Mensah RK, Madden JL. 1994. Life table and key factor studies of *Ctenarytaina thysanura* Ferris and Klyver (Hemiptera: Psyllidae) on *Boronia megastigma* Nees. ex Bartl. (Rutaceae) in Tasmania. *J Aust Entomol Soc.* 33:353–361.
- Messi J. 1983a. Facteurs influencant le comportement de ponte de *Mesohomotoma tessmanni* Aulmann, psylle parasite de cacoyer. *Bull Soc Entomol Fr.* 88:368–374.
- Messi J. 1983b. Influence of temperature and photoperiod on the embryonic and postembryonic development of *Mesohomotoma tessmanni* Aulmann (Homoptera, Psyllidae) a pest of the cacao plant. *Bull Inst Fondam Afr Noire, Ser A, Sci Nat.* 45:274–287.
- Messi J, Tamesse JL. 1999. Fluctuations numeriques des populations de *Trioza erythrae* (Del Guercio), psylle des agrumes dans un verger fruitier a Yaounde (Hemiptera: Psylloidea: Triozidae). *Ann Soc Entomol Fr.* 35:238–241.
- Mifsud D. 1997. The jumping plant-lice (Hemiptera: Psylloidea) of the Maltese Islands [masters thesis]. [Msida (Malta)]: University of Malta. 84 p.
- Migula P, Glowacka E, Krawczyk A. 1980. Respiratory metabolism in jumping plant lice (Psylloidea, Homoptera). *Prace Naukowe Uniwersytetu Slaskiego w Katowicach* 375:185–205.
- Miles HW. 1928. The bay psyllid. *Northwest Nat, Arbroath.* 3:8–14.
- Miles JE, Bale JS, Hodkinson ID. 1997. Effects of temperature elevation on the population dynamics of the upland heather psyllid *Strophingia ericae* (Curtis) (Homoptera: Psylloidea). *Global Change Biol.* 3:291–297.
- Miles JE, Bale JS, Hodkinson ID. 1998. Life cycle regulation in the heather psyllid *Strophingia ericae*: responses to temperature and photoperiod. *Physiol Entomol.* 23:376–381.
- Missonnier J. 1956. Note sur la biologie du psylle de l'aubepine (*Psylla peregrina*). *Ann Epiphyt* 7:253–262.

- Miyatake Y. 1968a. A new Japanese species of *Trioza* from *Machilus thunbergii*, with descriptions of the immature stages and notes on biology. *Trans Shikoku Entomol Soc.* 10:1–10.
- Miyatake Y. 1968b. *Pachypsylla japonica* sp. nov., a remarkable lerp-forming psyllid from Japan (Homoptera: Psyllidae). *Bull Osaka Mus Nat Hist.* 21:5–12.
- Miyatake Y. 1969. On the life history and the immature stages of *Trioza cinnamomi* (Boselli), with the redescription of the adult (Homoptera: Psyllidae). *Bull Osaka Mus Nat Hist.* 22:19–30.
- Miyatake Y. 1970. Some taxonomical and biological notes on *Togepssylla matsumurana* Kuwayama (Hem., Psyllidae). *Bull Osaka Mus Nat Hist.* 23:1–10.
- Miyatake Y. 1973. Notes on the genus *Euphalerus* of Japan with description of a new species (Homoptera Psyllidae). *Bull Osaka Mus Nat Hist.* 27:23–28.
- Miyatake Y. 1978. Notes on the genus *Epitrioza* of Japan with descriptions of two new species (Homoptera: Psyllidae). *Bull Osaka Mus Nat Hist.* 31:93–111.
- Miyatake Y. 1980. Notes on the genus *Pachypsylla* of Japan with description of *Pachypsylla usubai* new species (Homoptera: Psyllidae). *Bull Osaka Mus Nat Hist.* 33:61–70.
- Miyatake Y. 1992. A revision of the genus *Calophya* from Japan (Homoptera: Psylloidea). *Bull Osaka Mus Nat Hist.* 46:11–23.
- Miyatake Y. 1994. Further knowledge on the distribution and biology of two species of the genus *Celtisaspis* (Homoptera: Psylloidea: Spondylaspididae). *Bull Osaka Mus Nat Hist.* 48:27–30.
- Mohammed MA, Sheet AI. 1989. Ecological study on the pistachio psyllid (*Agonoscena targionii* (Licht.)) (Homoptera, Psyllidae) in Mosul region, Iraq. *Arab J Plant Prot.* 7:138–142.
- Mondal S, Ray R, Mukhopadhyay TK. 2003. Destruction of *Areca catechu* by *Psylla* sp. (Homoptera: Psyllidae). *Bionotes* 5:93.
- Monobrullah M, Singh PP, Singh R. 1998. Life-history and morphology of different stages of mango shoot gall psyllid, *Apsylla cistellata* Buckton (Homoptera: Psyllidae). *J Entomol Res, N Delhi.* 22:319–323.
- Moore KM. 1961. Observations on some Australian forest insects 8. The biology and occurrence of *Glycaspis baileyi* Moore in New South Wales. *Proc Linn Soc NSW.* 86:185–200.
- Moore KM. 1983. New species and records of *Glycaspis* Taylor (Homoptera, Spondylaspididae) with phyletic groupings. *J Aust Entomol Soc.* 22:177–184.
- Moran VC. 1968a. The development of the citrus psylla *Trioza erytreae* (Homoptera, Psyllidae) on *Citrus limon* and four indigenous host plants. *J Entomol Soc South Afr.* 31:391–402.
- Moran VC. 1968b. Preliminary observations on the choice of host plants by adults of the citrus psylla *Trioza erytreae* (Homoptera: Psyllidae). *J Entomol Soc South Afr.* 31:403–410.
- Moran VC, Blowers JR. 1967. On the biology of the South African citrus psylla, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae). *J Entomol Soc S Afr.* 30:96–106.
- Moran VC, Brown RP. 1973. The antennae, chemoreception and probing activity of the citrus psylla *Trioza erytreae* (Del Guercio) (Homoptera:Psyllidae). *J Entomol Soc S Afr.* 36:191–202.
- Moran VC, Buchan PR. 1975. Oviposition by the citrus psylla *Trioza erytreae* (Homoptera, Psyllidae) in relation to leaf hardness. *Entomol Exp Appl.* 18:96–104.
- Morath SU, Pratt PD, Silvers CS, Center TD. 2006. Herbivory by *Boreioglycaspis melaleucae* (Homoptera: Psyllidae) accelerates foliar senescence and abscission in the invasive tree *Melaleuca quinquenervia*. *Environ Entomol.* 35:1372–1378.
- Morgan FD. 1984. Psylloidea of South Australia. Woolman DJ, editors. *Handbook of the Flora and Fauna of South Australia*. Adelaide: South Australia, Illustrated. Paper.

- Morgan FD, Taylor GS. 1988. The white lace lerp in southeastern Australia. In: Berryman AA, editor. Dynamics of forest insect populations. patterns, causes, implications. London: Plenum Press. p. 130–140.
- Moxon JE. 1984. D.P.I. Entomology Bulletin 43, Psyllid pest of *Leucaena*. Harvest 12:19–22.
- Mullen BF, Shelton HM. 2003. Psyllid resistance in *Leucaena*. Part 2. Quantification of production losses from psyllid damage. *Agrofor Syst.* 58:163–171.
- Munro JA. 1965. Occurrence of *Psylla uncatoides* on *Acacia* and *Albizzia* with notes on control. *J Econ Entomol.* 58:1171–1172.
- Munyanza JE, Crosslin JM, Upton JE. 2007. Association of *Bactericera cockerelli* (Homoptera: Psyllidae) with “zebra chip”, a new potato disease in southwestern United States and Mexico. *J Econ Entomol.* 100:656–663.
- Mustafa TM. 1984. Factors affecting the distribution of *Euphyllura olivina* (Hom. Psyllidae) on olive. *Z Angew Entomol.* 97:371–375.
- Mustafa TM. 1989a. Bionomics of the olive psylla *Euphyllura olivina* Costa (Hom. Psyllidae) in Jordan. *J Biol Sci Res.* 20:159–166.
- Mustafa TM. 1989b. Seasonal changes in fat and water content in field populations of olive psylla *Euphyllura olivina* Costa (Homoptera, Psyllidae). *Insect Sci Appl.* 10:181–186.
- Mustafa TM, Hodgson CJ. 1984. Observation, diapause induction and termination in *Psylla pyricola* in England. Lutte intégrée contre les psylles du poirier, *Bull OILB/SROP,* 127–138.
- Mustafa TM, Najjar YH. 1985. Contributions to the reproductive biology of olive psylla *Euphyllura olivina* (Homoptera, Psyllidae). *Z Angew Entomol.* 100:79–83.
- Naeem A, Behad E. 1988. The biology of the gas psyllid. *Entomol Phytopathol A.* 55:111–121.
- Nakata T. 2006. Temperature-dependent development of the citrus psyllid, *Diaphorina citri* (Homoptera: Psylloidea), and the predicted limit of its spread based on overwintering in the nymphal stage in temperate regions of Japan. *Appl Entomol Zool.* 41:383–387.
- Nava DE, Torres MLG, Rodrigues MDL, Bento JMS, Parra JRP. 2007. Biology of *Diaphorina citri* (Hem., Psyllidae) on different hosts and at different temperatures. *J Appl Entomol.* 131:709–715.
- Negi DS, Bisht RS. 1989. On the biology of the psyllid *Pauropsylla depressa* Crawford (Homoptera: Psyllidae). *Uttar Pradesh J Zool.* 9:253–257.
- Nguyen T-X. 1963. Note préliminaire sur quelques psyllides du sud-ouest de la France. *Rev Pathol Veg Entomol Agri Fr.* 42:169–176.
- Nguyen T-X. 1964. Observations préliminaires concernant l'élimination de la diapause chez *Psylla pyri* L. *Rev Pathol Veg Entomol Agri Fr.* 43:3–12.
- Nguyen T-X. 1965. Observations sur la ponte préférentielle de *Psylla buxi* L (Homopteres Psyllides) sur les différentes variétés de buis. *Bull Soc Hist Nat Toulouse.* 100:299–311.
- Nguyen T-X. 1967a. Influence des facteurs externes sur l'élimination anticipée de la diapause de *Psylla pyri* L. (Homoptères-Psyllidae). *Comptes Rendus Acad Sci, Paris Ser D.* 264:1445–1448.
- Nguyen T-X. 1967b. Observations sur l'élimination de la diapause de *Psylla pyri* (Hom. Psyllidae) dans les conditions naturelles. *Ann Soc Entomol Fr (New Ser.)* 3:151–164.
- Nguyen T-X. 1968. Rôle de la température dans l'évolution et élimination de la diapause larvaire de *Psylla buxi* (Hom. Psyllidae). *Ann Soc Entomol Fr (New Ser.)* 4:69–74.
- Nguyen T-X. 1969. Étude de la résistance au froid et de la capacité d'acclimation de *Psylla buxi* L (Homoptera: Psyllidae). *Comptes Rendus Acad Sci, Paris Ser D.* 268:1410–1413.
- Nguyen T-X. 1970a. Influence de la température et de la photopériode sur la reproduction d'un psylle du poirier, *Psylla pyri* L. (Insecte: Homoptera-Psyllidae). *Comptes Rendus des Academie de Sciences, Paris Ser D.* 271:2336–2338.
- Nguyen T-X. 1970b. Recherches sur la morphologie et la biologie de *Psyllopsis fraxini* (Hom. Psyllidae). *Ann Soc Entomol Fr (New Ser.)* 6:757–773.



- Nguyen T-X. 1971. Effet de groupement sur la reproduction et la longévité de *Psylla pyri* L. (Insectes, Homoptera-Psyllidae). Comptes Rendus Acad Sci, Paris Ser D. 272:1782–1784.
- Nguyen T-X. 1972a. Études de la diapause imaginale de *Psylla pyri* L. (Homoptera: Psyllidae) 1. Déterminisme du polymorphisme saisonnier des adultes. Ann Zool Ecol Anim. 4:281–309.
- Nguyen T-X. 1972b. Influence de la nature des plantes hôtes sur la longévité et la fécondité de *Psylla pyri* (L.) (Insecte, Homoptera-Psyllidae). Comptes Rendus Acad Sci, Paris Ser D. 274:546–548.
- Nguyen T-X. 1973. Action de surpeuplement sur la reproduction de *Psylla pyri* (L.) (Insectes, Homoptere, Psyllidae). Comptes Rendus Acad Sci, Paris Ser D. 276:2389–2390.
- Nguyen T-X. 1975. Évolution et la termination de la diapause ovarienne de *Psylla pyri* (Homoptera-Psyllidae) dans les conditions naturelles de la région Toulousaine. Bull Soc Zool Fr. 100:241–246.
- Nguyen T-X. 1985. Établissement d'une échelle morphométrique pour les Psyllidae (Insecta-Homoptera); polymorphisme saisonnier de *Psylla pyri* L. Comptes Rendus Acad Sci, Paris Ser D. 301:369–372.
- Nguyen T-X, Ledoux A. 1973. Évolution de la diapause ovarienne des femelles de *Psylla pyri* L. (Homoptera: Psyllidae) pendant la période automne-hiver. Comptes Rendus Acad Sci, Paris Ser D. 277:2385–2387.
- Nguyen T-X, Messi J. 1973. Observations sur la ponte des femelles de *Arytaina genistae* élevée sur des genets d'origine différente. Comptes Rendus Acad Sci, Paris Ser D. 276:1691–1696.
- Nissinen A, Ibrahim M, Kainulainen P, Tiilikkala K, Holopainen JK. 2005. Influence of carrot psyllid (*Trioza apicalis*) feeding or exogenous limonene or methyl jasmonate treatment on composition of carrot (*Daucus carota*) leaf essential oil and headspace volatiles. J Agri Food Chem. 53:8631–8638.
- Nissinen A, Vanhala P, Holopainen JK, Tiilikkala K. 2007. Short feeding period of carrot psyllid (*Trioza apicalis*) females at early growth stages of carrot reduces yield and causes leaf discolouration. Entomol Exp Appl. 125:277–283.
- Nucifora A. 1969. La *Psylla piri* (L.) nei frutteti dell'Etna. Tecnica Agri, Catania 21: 348–361.
- Ogol CKPO, Spence JR. 1997. Abundance, population dynamics and impact of the leucaena psyllid *Heteropsylla cubana* Crawford in a maize-leucaena agroforestry system in Kenya. Insect Sci Appl. 17:183–192.
- Oka IN, Bahgiawati AH. 1988. Comprehensive program towards integrated control of *Leucaena* psyllid, a new insect pest of *Leucaena* trees in Indonesia. Indones Agri Res Devel J. 10:23–30.
- Oldfield GN. 1970. Diapause and polymorphism in California populations of *Psylla pyricola* (Homoptera. Psyllidae). Ann Entomol Soc Am. 63:180–184.
- Olivares TS. 2000. *Ctenarytaina eucalypti* (Maskell, 1890): el psilido de eucalipto en Chile (Hemiptera: Sternorrhyncha: Psylloidea: Spondylaspiinae). Gayana 64:239–241.
- Omole MM. 1980. Attraction to colour traps and height of flight in *Trioza urticae* (Hemiptera, Heteroptera, Psyllidae). Entomol Mon Mag. 116:173–175.
- Onillon JC. 1969. Effect of the numerical density of *Trioza urticae* (Homoptera, Psyllidae) on the ovarian activity of *Tetrastichus upis* (Hymenoptera, Tetrastichidae). In: Labeyrie V, editor. Colloques internationaux de centre national de la recherche scientifique No. 189. l'influence des stimuli externes sur la gametogenese des insectes. Paris (France): Centre National de la Recherche Scientifique. p. 57–70.
- Osborn H. 1922. Life history notes on Cranberry Lake Homoptera. Technical Publication of the New York State College of Forestry at Syracuse 16:87–104.
- Osisanya EO. 1974a. Aspects of the biology of *Diclidophlebia eastopi* and *Diclidophlebia harrisoni* (Homoptera: Psyllidae). Bull Entomol Res. 64:9–18.

- Osisanya EO. 1974b. Seasonal fluctuations of a natural population of *Diclidophlebia eastopi* and *Diclidophlebia harrisoni* (Homoptera: Psyllidae). Bull Entomol Res. 64:289–296.
- Ossiannilsson F. 1943. Studier over de Svenska potatifaltens insectfauna och dess betydelse for spridning av virussjukdomar. 1. Hemiptera, Forekomst och utbredning. Statens Vaxtskyddsanstalt Medd. 39:1–72.
- Ossiannilsson F. 1950. Sound production in psyllids (Hem. Hom.). Opusc Entomol. 11:82–84.
- Ossiannilsson F. 1992. The Psylloidea (Homoptera) of Fennoscandia and Denmark. Fauna Entomol Scand. 26:1–347.
- Palmer WA, Witt ABR. 2006. On the host range and biology of *Acizzia melanocephala* (Homoptera: Psyllidae), an insect rejected for the biological control of *Acacia nilotica* subsp *indica* (Mimosaceae) in Australia. Afr Entomol. 14:387–390.
- Pande YD. 1971. Biology of citrus psylla *Diaphorina citri* (Homoptera, Homoptera, Psyllidae). Israel J Entomol. 6:307–311.
- Papp RP, Johnson JB. 1979. Origins of psyllid fallout in the central Sierra-Nevada of California. Pan-Pac Entomol. 55:95–98.
- Parkinson JD, Whittaker JB. 1975. A study of two physiological races of the heather psyllid *Strophingia ericae* (Homoptera, Psylloidea). Biol J Linn Soc. 7:73–81.
- Pasqualini E, Civolani S, Musacchi S, Ancarani V, Dondini L, Robert P, Baronio P. 2006. *Cacopsylla pyri* behaviour on new pear selections for host resistance programs. Bull Insectol. 59:27–37.
- Patch EM. 1909. Downy psyllid of alder, *Psylla floccosa*, new species. Can Entomol. 41:301–303.
- Patil NG, Baker PS, Pollard GV. 1994. Life history parameters of the leucaena psyllid *Heteropsylla cubana* (Crawford) (Homoptera: Psyllidae) under various temperature and relative humidity regimes. Insect Sci Appl. 15:293–299.
- Pava OJ, Gonzalez OA, Castillo CE, Patino CH. 1983. Interesting phyto sanitary aspects of the chontaduro palm *Bactris gasipaes* in some regions of Valle and Choco, Colombia. Acta Agron Palmira 33:25–36.
- Peck SB. 1994. Aerial dispersal of insects between and to islands in the Galapagos Archipelago, Ecuador. Ann Entomol Soc Am. 87:218–224.
- Pedata PA. 1998. Morpho-biological observations on *Egeirotrioza (Astutia) populi* Horvath, new for Italy. Atti Accad Roveretana Degli Agiati (Series VII) 8B:75–86.
- Percy DM. 2003a. Legume-feeding psyllids (Homoptera, Psylloidea) of the Canary Islands and Madeira. J Nat Hist. 37:397–461.
- Percy DM. 2003b. Radiation, diversity, and host-plant interactions among island and continental legume-feeding psyllids. Evolution 57:2540–2556.
- Percy DM, Page RDM, Cronk QCB. 2004. Plant-insect interactions: Double-dating associated insect and plant lineages reveals asynchronous radiations. Syst Biol. 53:120–127.
- Percy DM, Taylor GS, Kennedy M. 2006. Psyllid communication: acoustic diversity, mate recognition and phylogenetic signal. Invertebr Syst 20:431–445.
- Perez Otero R, Mansilla Vazquez JP, Mansilla Salinero P. 2005. Distribucion y biologia de *Ctenarytaina spatulata* Taylor sobre *Eucalyptus globulus* Labill. en la provincia de Pontevedra. Bol Sanid Veg Plagas. 31:25–30.
- Petersen A. 1923. The blackberry psyllid, *Trioza tripunctata* Fitch. Bull NJ Agri Exp Stn. 378:1–32.
- Pfeiffer DG, Burts EC. 1983. Effects of tree fertilization on numbers and development of pear psylla *Psylla pyricola* (Homoptera: Psyllidae) and on fruit damage. Environ Entomol. 12:895–901.
- Pfeiffer DG, Burts EC. 1984. Effect of tree fertilization on protein and free amino-acid content and feeding rate of pear psylla *Psylla pyricola* (Homoptera Psyllidae). Environ Entomol. 13:1487–1490.

- Pintera A. 1982. Some observations on the ecology and population dynamics of psyllas found on cedar. *Poeyana Inst Zool Acad Ciencias Cuba*. 252:1–12.
- Pletsch DJ. 1947. The potato psyllid *Paratrioza cockerelli* (Šulc). Its biology and control. *Bull Montana Agri Exp Stn*. 446:1–95.
- Prasad D. 1957. On the distribution, bionomics, and control of the mango shoot gall psyllid, *Apsylla cistellata* Buckton. *Indian J Entomol*. 19:78–83.
- Prophetou DA. 1993. Diapause termination and phenology of the olive psyllid, *Euphyllura phillyreae* on two host plants in coastal northern Greece. *Entomol Exp Appl*. 67:193–197.
- Prophetou DA. 1997. Occurrence of immature stages of olive psyllid *Euphyllura phillyreae* (Hom, Aphalaridae) in *Phillyrea latifolia* and *Olea europaea* in coastal northern Greece. *J Appl Entomol*. 121:383–387.
- Prophetou DA, Tzanakakis ME. 1977. Seasonal development and number of generations of *Euphyllura olivina* (Hemiptera-Psyllidae) in Halkidiki (N Greece). *Ann Entomol Soc Am*. 70:707–710.
- Prophetou DA, Tzanakakis ME. 1986. Diapause termination in the olive psyllid *Euphyllura phillyreae* in the field and in the laboratory. *Entomol Exp Appl*. 40:263–272.
- Przybylski Z. 1970. Studies on the synchronization of phytophenological phenomenon with the development of *Psylla mali* (Psyllidae). *Ekol Polska Ser A*. 18:1–40.
- Purcell MF, Balciunas JK, Jones P. 1997. Biology and host-range of *Boreioglycaspis melaleuca* (Hemiptera: Psyllidae), potential biological control agent for *Melaleuca quinquenervia* (Myrtaceae). *Environ Entomol*. 26:366–372.
- Purcell AH, Suslow KG. 1984. Surveys of leafhoppers (Homoptera: Cicadellidae) and pear psylla (Homoptera: Psyllidae) in pear and peach orchards and the spread of peach yellow leaf roll disease. *J Econ Entomol*. 77:1489–1494.
- Purvis G, Chauzat MP, Segonds-Pichon A, Dunne R. 2002. Life history and phenology of the eucalyptus psyllid, *Ctenarytaina eucalypti* in Ireland. *Ann Appl Biol*. 141:283–292.
- Pussard MR. 1939. Contribution a l'étude de la nutrition des psyllides. Presence d'une amylase dans les glandes salivaires de quelques psyllides adultes. *Comptes Rendus Soc Savantes Paris* 71:291–292.
- Puterka GJ. 1997. Intraspecific variation in pear psylla (Psyllidae: Homoptera) nymphal survival and development on resistant and susceptible pear. *Environ Entomol*. 26:552–558.
- Puterka GJ, Bell RL, Jones SK. 1993. Ovipositional preference of pear psylla (Homoptera, Psyllidae) for resistant and susceptible pear. *J Econ Entomol*. 86:1297–1302.
- Radjabi G, Behechti ND. 1975. Bioecological studies and control of *Psylla pyricola* (Homoptera, Psyllidae) in Esfahan. *Entomol Phytopathol Appl*. 39:39–53.
- Rajadurai S, Mani T, Balakrishna P, Raman A. 1990. On the digestive enzymes and soluble proteins of the nymphal salivary glands of *Triozia jambolanae* Crawford (Triozinae: Psyllidae: Homoptera), the gall maker on the leaves of *Syzygium cumini* (L.) Skeels (Myrtaceae). *Phytophaga* 3:47–53.
- Rajapakse RHS, Kulasekera K. 1982. Some observations on the insect pests of cinnamon in Sri Lanka. *Entomon* 7:221–223.
- Raman A. 1987. On the cecidogenesis and nutritive tissues of the leaf galls of *Garuga pinnata* Roxburgh (Burseraceae) induced by *Phacopteron lentiginosum* Buckton (Pauropsyllinae: Psyllidae: Homoptera). *Phytophaga* 1:141–159.
- Raman A. 1991. Cecidogenesis of leaf galls on *Syzygium cumini* (L.) Skeels (Myrtaceae) induced by *Triozia jambolanae* Crawford (Homoptera, Psylloidea). *J Nat Hist*. 25:653–663.
- Raman A. 1994. Adaptational integration between gall-inducing insects and their host plants. In: Ananthakrishnan TN, editor. *Functional dynamics of phytophagous insects*. New Delhi (India): Oxford & IBH Publishing Co. p. 249–275.

- Raman A. 2003. Cecidogenetic behavior of some gall-inducing thrips, psyllids, coccids, and gall midges, and morphogenesis of their galls. *Oriental Insects* 37:359–413.
- Ramert B, Nehlin G. 1989. Alternative plant protection methods in small scale cultivation. *Vaxtskyddsnotiser Suppl.* 2:1–39.
- Ramirez Gomez C. 1956. Los psilidos de Espana. *Bol Real Soc Esp Hist Nat (Biol.)* 53:151–219.
- Ramirez Gomez C. 1958. Los psilidos de Espana. *Bol Real Soc Esp Hist Nat (Biol.)* 54:63–106.
- Ramirez Gomez C. 1960. Los psilidos de Espana. *Bol Real Soc Esp Hist Nat (Biol.)* 57:4–87.
- Rapisarda C. 1985. Sulla presenza in Italia di *Acizzia acaciae baileyanae* (Froggatt) (Homoptera, Psylloidea), nuovo parassita di acacie ornamentali. *Inf Fitopatol.* 35:45–49.
- Rapisarda C. 1988. Note tassonomiche e bio-ecologiche sulle specie di psilloidei viventi su Genistinae in Sicilia (Homoptera). In: *Proceedings of the XV Italian National Congress of Entomology, l'Aquila.* p. 497–504.
- Rapisarda C. 1989a. Contributo alla conoscenza degli psilloidei viventi su *Rhamnus alaternus* L. in Italia (Homoptera: Psylloidea). *Phytophaga* 3:21–60.
- Rapisarda C. 1989b. Presenza in Sicilia della psilla verde del fico (*Homotoma viridis* Klimaszewski) e descrizione della sua ninfa di ultima eta (Homoptera: Psylloidea). *Bol Soc Entomol Ital.* 121:13–18.
- Rapisarda C. 1989c. A new Sicilian species of *Arytainilla* Loginova (Homoptera: Psylloidea), from *Genista aetensis* (Biv.) DC, with notes on its biology. *Frustula Entomol (New Ser.)* 9:23–39.
- Rapisarda C. 1990a. Faunistic and ecological notes on the psyllids of Sardinia (Homoptera: Psylloidea). *Mem Soc Entomol Ital.* 69:7–52.
- Rapisarda C. 1990b. Morphological and biological notes on *Arytainilla cytisi* (Homoptera, Psylloidea). *Phytophaga* 3:115–130.
- Rapisarda C. 1992. Nymphal description and life-cycle of *Livilla retamae* (Puton) and *Livilla spectabilis* (Flor) (Homoptera Psylloidea). *Boll Zool Agrar Bachic.* 24:195–204.
- Rapisarda C. 1993a. Seasonal dimorphism in two *Acacia*-feeding psyllids of the genus *Acizzia* (Homoptera: Psylloidea). *Phytophaga* 3:131–146.
- Rapisarda C. 1993b. *Trioza soniae* and *T. apulica* n. spp., on *Quercus* spp., from southern Italy. *Mem Soc Entomol Ital.* 72:175–188.
- Rapisarda C. 1998. New data on the Sicilian psyllids (Homoptera: Psylloidea). *Atti Accad Roveretana Degli Agiati (Ser VII).* 8B:97–104.
- Rapisarda C, Belcari A. 1999. Notes on some psyllids (Homoptera: Psylloidea) infesting urban trees in Italy. In: Lemattre M, Lemattre P, Lemaire F, editors. *International symposium on urban tree health.* Louvain (Belgium): International Society Horticultural Science. p. 155–164.
- Rasmy AM, MacPhee AW. 1970. Studies on the pear psylla in Nova Scotia. *Can Entomol.* 102:586–591.
- Rauf A, Hidayat P, Maryana N, Winasa IW. 1990. Biology and demography of *Heteropsylla cubana* Crawford (Homoptera: Psyllidae). In: Napompeth NA, editor, *Leucaena psyllid: problems and management.* Bangkok: Winrock Institute of Agricultural Development. p. 114–118.
- Reuter OM. 1909. Charakteristik und Entwicklungsgeschichte der Hemipteren-Fauna (Heteroptera, Auchenorrhyncha und Psyllidae) der Palaearctischen Coniferen. *Acta Soc Sci Fenn.* 36:1–129.
- Richards BL, Blood HL. 1933. Psyllid yellows of the potato. *J Agri Res.* 46:189–216.
- Riemann JG. 1958. Notes on the host and biology of *Tetragonocephala flava* Crawford (Homoptera: Psyllidae). *J Kansas Enomol Soc.* 31:256.
- Rieux R, D'Arcier FF. 1990. Seasonal polymorphism of *Psylla pyri* L. (Homoptera, Psyllidae) adults in natural populations. *J Appl Entomol.* 109:120–135.

- Riley CV. 1890. Hackberry psyllids. In: Packard AS, editor. Forest and shade tree insects. United States Entomological Commission 5th Report, Washington. p. 614–622.
- Ross WA. 1919. The pear psylla in Ontario. Annu Rep Entomol Soc Ont. 49:81–90.
- Russell LM. 1971. Notes on *Euphalerus nidifex* Schwarz and related nest-making New World psyllids. Fl Entomol. 54:3–12.
- Rygg T. 1977. Biological investigations on carrot psyllid *Trioza apicalis* Forster (Homoptera, Triozidae). Meldinger Nor Landbrukshogskole 56:1–20.
- Saiz F, Nunez C. 2000. Cecidias de hoja y de rama de *Schinus polygamus* (Cav.) Cabr. (Anacardiaceae): doble agente formador o secuencia temporal de cecidias formadas por huespedes diferentes? Rev Chilena Entomol. 27:57–63.
- Sampo A. 1975. Di alcuni psilloceci nuovi o poco noti della valle d'Aosta. Rev Valdotaïne Hist Nat (Aosta) 29:153–174.
- Sampo A. 1977. La psilla del lauro (*Trioza alacris* Flor). Il Floriculture, Milan 14:79–83.
- Samways MJ. 1987. Weather and monitoring the abundance of the adult citrus psylla *Trioza erythrae* Del Guercio (Homoptera, Triozidae). J Appl Entomol. 103:502–508.
- Sanford GB. 1952. Phloem necrosis of potato tubers associated with infestation of vines by *Paratrioza cockerelli* Šulc. Sci Agri. 32:433–439.
- Sasaki C. 1910. On the life history of *Trioza camphorae* n.sp. of camphor tree and its injuries. J Coll Agri Imperial Univ Tokyo. 2:277–285.
- Savinelli CE, Tetrault RC. 1984. Analysis of pear psylla (Homoptera: Psyllidae) populations and associated damage in a Pennsylvania pear orchard. Environ Entomol. 13:278–281.
- Schaefer HA. 1949. Biologische und ökologische Beobachtungen an Psylliden (Hemiptera). Verhandlungen Naturforschenden Ges Basel 60:25–41.
- Schaub L, Graf B, Butturini A. 2005. Phenological model of pear psylla *Cacopsylla pyri*. Entomol Exp Appl. 117:105–111.
- Schmidt E. 1966. Cycle biologique et phases cecidogenes de *Livia juncorum* Latr. Marcellia 33:223–235.
- Scutareanu P, Loxdale HD. 2006. Ratio of nutrient and minerals to defensive compounds indicative of plant quality and tolerance to herbivory in pear trees. J Plant Nutr. 29:629–642.
- Shahid M, Khan S. 1976. Biology and control of *Diaphorina citri* Kuw (citrus psylla) in Pashawar. Pakistan J Sci Res. 28:24–28.
- Siddiqui ZA. 1949. Occurrence of *Psyllia pyricola* Forst on apple and pear trees in Kamaum. Indian J Entomol. 8:237.
- Silvestri F. 1934. Psyllidae. Compendio di Entomologia Applicata. Portici: Tipografia Ballavista. p. 368–387.
- Singh G, Misra PN. 1978. The mango shoot gall psyllid *Apsylla cistellata* Buckton and its control. Pesticides 12:15–16.
- Singh MP. 1959. Studies on the mango shoot gall psyllid *Apsylla cistellata* l. Description of development stages and habits. Indian J Entomol. 21:273–281.
- Singh P. 1988. *Heteropsylla cubana* Crawford, a new pest of *Leucaena* in India. Indian For. 114:200–205.
- Singh SM. 1954. Studies on *Apsylla cistellata* Buckton causing mango galls in India. J Econ Entomol. 47:563–564.
- Singh SM. 1960. Studies on the mango shoot gall in Tarai region of UP, its causes and control. II Distribution, nature, extent, intensity of damage and bionomics of the pest. Horti Adv. 4:97–114.
- Sirrine FA. 1895. The bramble flea louse. Annu Rep NY State Agri Exp Stn. 14:619–623.
- Skanland HT, Sömme L. 1981. Seasonal-variation in cold-hardiness of eggs of the apple psyllid *Psylla mali* (Schmidb.) in Norway. Cryo-Letters 2:87–92.
- Slingerland MV. 1892. The pear tree psylla. Cornell Univ Agri Exp Stn Bull. 44:161–186.

- Smith JB. 1911. The bramble flea louse *Trioza tripunctata* Fitch. Annu Rep NJ Agri Exp Stn. 32:416–418.
- Smith RC, Taylor RS. 1953. The biology and control of the hackberry psyllids in Kansas. J Kansas Enomol Soc. 26:103–115.
- Solomon ME. 1936. Description and life-history of a new western Australian psyllid. J R Soc West Aust. 22:41–48.
- Sorin M. 1959a. On the life history and immature stages of *Trioza camphorae* Sasaki (Psyllidae, Homoptera). Kontyu 27:244–248.
- Sorin M. 1959b. On the life history and immature stages of *Trioza remota* Foerster (Homoptera: Psyllidae). Kontyu 27:181–186.
- Souliotis C, Broumas T. 1998. Study of the population dynamics of the *Cacopsylla pyri* L. (Homoptera: Psyllidae) and its predators in Eastern Attiki. Ann Inst Phytophathol Benaki. 18:97–109.
- Souliotis C, Tsourgianni A. 2000. Population dynamics of Psyllidae on pistachio (*Pistacia vera*): Bioecological data on *Agonoscena pistaciae* Burck. and Laut. (Homop. Sternorrhyncha). Boll Zool Agrar Bachic. 32:49–58.
- Spaulding AW, von Dohlen CD. 1998. Phylogenetic characterization and molecular evolution of bacterial endosymbionts in psyllids (Hemiptera: Sternorrhyncha). Mol Biol Evol. 15:1506–1513.
- Spaulding AW, von Dohlen CD. 2001. Psyllid endosymbionts exhibit patterns of co-speciation with hosts and destabilizing substitutions in ribosomal RNA. Insect Mol Biol. 10:57–67.
- Speyer W. 1929. Der Apfelblattsauger, *Psylla mali* Schmidb. Berlin (Germany): Springer.
- Staples R. 1968. Cross protection between a plant virus and potato psyllid yellows. J Econ Entomol. 61:1378–1380.
- Stavraki HG. 1980. Biologie de *Euphyllura* sp. (Homoptera: Psyllidae) dans un oliveraie d'attiki (Greece). Mededelingen van de Faculteit Landbouwwetenschappen, Universiteit Gent 45:603–611.
- Stratopoulou ET, Kapatatos ET. 1995a. Distribution of population of immature stages of pear psylla, *Cacopsylla pyri*, within the tree and development of sampling strategy. Entomol Hell. 10:5–10.
- Stratopoulou ET, Kapatatos ET. 1995b. The dynamics of the adult population of pear psylla, *Cacopsylla pyri* L. (Hom., Psyllidae) in the region of Magnesia (Greece). J Appl Entomol. 119:97–101.
- Stromgren ES, Lanciani CA. 2001. Early abscission in hackberry leaves bearing *Pachypsylla* galls (Homoptera: Psyllidae). Fl Entomol. 84:727–728.
- Stuart LC. 1991. Blackberry psyllid. In: Ellis MA, Converse RH, Williams RN, Williamson B, editors. Compendium of raspberry and blackberry diseases and insects. St. Paul (MN): American Phytopathological Society Press. p. 73–74.
- Stuart LC, Butt BA, Bell RL. 1989. Effect of host phenology on ovipositional preference of winter form pear psylla (Homoptera, Psyllidae). J Entomol Soc BC. 86:34–38.
- Sutton RD. 1983. Seasonal colour changes, sexual maturation and oviposition in *Psylla peregrina* (Homoptera: Psylloidea). Ecol Entomol. 8:195–202.
- Sutton RD. 1984. The effect of host plant flowering on the distribution and growth of hawthorn psyllids (Homoptera, Psylloidea). J Anim Ecol. 53:37–50.
- Swenk MH, Tate HD. 1940. The potato flea beetle and the potato psyllid in Nebraska. Bull Neb Agri Exp Stn. 327:1–19.
- Takara JM, Dinker RJ, Nagamine WT, Teramoto KK. 1990. Biology and reproductive rate of leucaena psyllid, *Heteropsylla cubana* Crawford. Proc Hawaiian Entomol Soc. 30:23–30.
- Tamesse JL, Messi J. 2004. Facteurs influencant la dynamique des populations du psylle africain des agrumes *Trioza erytrae* Del Guercio (Hemiptera: Triozidae) au Cameroun. Int J Trop Insect Sci. 24:213–227.

- Tarsia in Curia I. 1934. La simbiosi ereditaria in *Trioza alacris* Flor. Archiv Zool Ital. 2:215–235.
- Taylor GS. 1985. The taxonomic status of *Schedotrioza multitudinea* (Psylloidea: Triozidae) with notes on its biology. J Aust Entomol Soc. 24:305–312.
- Taylor GS. 1987. The gall forming Psylloidea of *Eucalyptus obliqua* in the Mount Lofty Ranges of South Australia. J Aust Entomol Soc. 26:223–228.
- Taylor KL. 1985. A possible stridulatory organ in some Psylloidea (Homoptera). J Aust Entomol Soc. 24:77–80.
- Tedeschi R, Alma A. 2004. Transmission of apple proliferation phytoplasma by *Cacopsylla melanoneura* (Homoptera: Psyllidae). J Econ Entomol. 97:8–13.
- Tedeschi R, Bosco D, Alma A. 2002. Population dynamics of *Cacopsylla melanoneura* (Homoptera: Psyllidae), a vector of apple proliferation phytoplasma in northwestern Italy. J Econ Entomol. 95:544–551.
- Tedeschi R, Ferrato V, Rossi J, Alma A. 2006. Possible phytoplasma transovarial transmission in the psyllids *Cacopsylla melanoneura* and *Cacopsylla pruni*. Plant Pathol. 55:18–24.
- Teixeira DD, Danet JL, Eveillard S, Martins EC, Junior WCJ, Yamamoto PT, Lopes SA, Bassanezi RB, Ayres AJ, Saillard C. 2005. Citrus huanglongbing in Sao Paulo State, Brazil: PCR detection of the “Candidatus” Liberibacter species associated with the disease. Mol Cell Probes. 19:173–179.
- Tenorio J, Chuquillanqui C, Garcia A, Guillen M, Chavez R, Salazar LF. 2003. Sintomatologia y efecto en el rendimiento de papa por el achaparramiento rugoso. Fitopatologia 38:32–36.
- Thakur JR, Sharma PC, Gupta PR. 1989. Occurrence of olive psylla *Euphyllura pakistanika* Loginova (Homoptera: Aphalaridae) on olive in India, a new record. Trop Pest Manag. 35:331.
- Thao ML, Clark MA, Baumann L, Brennan EB, Moran NA, Baumann P. 2000a. Secondary endosymbionts of psyllids have been acquired multiple times. Curr Microbiol. 41:300–304.
- Thao ML, Moran NA, Abbot P, Brennan EB, Burckhardt DH, Baumann P. 2000b. Cospeciation of psyllids and their primary prokaryotic endosymbionts. Appl Environ Microbiol. 66:2898–2905.
- Thao ML, Clark MA, Burckhardt DH, Moran NA, Baumann P. 2001. Phylogenetic analysis of vertically transmitted psyllid endosymbionts (Candidatus Carsonella ruddii) based on atpAGD and rpoC: Comparisons with 16S–23S rDNA-derived phylogeny. Curr Microbiol. 42:419–421.
- Thenmozhi K, Kandasamy C. 1992. Studies of the biology of gall psyllids of India 1. *Pauropsylla longispiculata* Mathur (Psyllidae, Homoptera). Agri Biol Res. 8:44–47.
- Tishechkin DY. 1989. Acoustic signalization in the psyllids (Homoptera, Psyllinea) from the Moscow Oblast, Russian SSR. Vestnik Moskovskogo Universiteta Seriya XVI Biologiya, 20–24.
- Tishechkin DY. 2005. Vibratory communication in Psylloidea (Hemiptera). In: Drosopoulos S, Claridge MM, editors. Insect sounds and communications. London: CRC Taylor & Francis. p. 357–363.
- Tishechkin DY. 2007. New data on vibratory communication in jumping plant lice of the families Aphalaridae and Triozidae (Homoptera, Psyllinea). Entomol Rev. 87:394–400.
- Tokmakoglu C. 1973. The studies on some features of biology and control methods of *Agonoscena targionii* Licht. Bitki Koruma Bülteni 13:67–72.
- Tremblay E. 1958. La *Trioza nigricornis* Foerster (Nota preliminare). Boll Lab Entomol Agrar Filippo Silvestri, Portici. 16:160–170.
- Tremblay E. 1961. La psilla e il misurino della cipolla. Laboratorio Enomologia Agrar “F. Silvestri” Oss Mal Piante, Portici, Circ. 24:1–10.

- Tremblay E. 1965a. Risultati di prove di lotta contro la psilla della cipolla (*Trioza tremblayi* Wagner). Ann Fac Sci Agrar Univ Napoli. 30:15–27.
- Tremblay E. 1965b. Studio morfo-biologico sulla *Trioza tremblayi* Wagner (Hemiptera: Homoptera, Psyllidae). Boll Lab Entomol Agrar Filippo Silvestri, Portici. 23:37–138.
- Tsai JH, Liu YH. 2000. Biology of *Diaphorina citri* (Homoptera: Psyllidae) on four host plants. J Econ Entomol. 93:1721–1725.
- Tuncer C. 2002. Investigations on the biology of *Homotoma ficus* L. (Homoptera: Homotomidae) and the development threshold for eggs in Samsun Province. Turkiye Entomol Dergisi 26:33–44.
- Tuthill LD. 1952. On the Psyllidae of New Zealand. Pac Sci. 6:83–125.
- Tzanakakis ME. 2003. Seasonal development and dormancy of insects and mites feeding on olive: a review. Neth J Zool. 52:87–224.
- Tzanakakis ME. 2006. Insects and mites feeding on olive. Distribution, importance, habits, seasonal development and dormancy. Leiden (The Netherlands): Brill.
- Uchida GK, Beardsley JWJ. 1988. Taxonomy and biology of *Megatrioza palmicola* group (Homoptera, Psyllidae) in Hawaii. Proc Hawaiian Entomol Soc. 28:57–100.
- Ullman DE, McLean DL. 1988a. Feeding behavior of the winter-form pear psylla *Psylla pyricola* (Homoptera, Psyllidae) on reproductive and transitory host plants. Environ Entomol. 17:675–678.
- Ullman DE, McLean DL. 1988b. The probing behavior of the summer-form pear psylla. Entomol Exp Appl. 47(2):115–126.
- Unruh TR, Krysan JL. 1994. Reproductive diapause and host plants affect insecticide tolerance of adult pear psylla (Homoptera, Psyllidae). J Econ Entomol. 87:858–865.
- Vaishampayan SM, Bahadur A. 1980. Observations on biology and bionomics of tendu gall fly, *Trioza obsoleta* Buckton (Homoptera: Psyllidae), and assessment of losses to tendu *Diospyros melanoxylon* Roxb. Proceedings of the 2nd Forestry Conference Dehra Dun, India. p. 1–7.
- van den Berg MA. 1990. The citrus psylla *Trioza erytrae* del Guercio (Hemiptera: Triozidae), a review. Agri Ecosyst Environ. 30:171–194.
- van den Berg MA, Anderson SH, Deacon VE. 1991. Population studies of the citrus psylla *Trioza erytrae*: factors influencing dispersal. Phytoparasitica 19:283–290.
- van den Berg MA, Deacon VE. 1988. Dispersal of the citrus psylla *Trioza erytrae* (Hemiptera, Triozidae) in the absence of its host plants. Phytophylactica 20:361–368.
- van den Berg MA, Deacon VE. 1989. Flight activities of the citrus psylla *Trioza erytrae* (Hemiptera, Triozidae). Phytophylactica 21:391–396.
- van den Berg MA, Deacon VE, Steenekamp PJ. 1991. Dispersal within and between citrus orchards and native hosts and nymphal mortality of citrus psylla *Trioza erytrae* (Hemiptera, Triozidae). Agri Ecosyst Environ. 35:297–310.
- van den Berg MA, Deacon VE, Thomas CD. 1991a. Ecology of the citrus psylla *Trioza erytrae* (Hemiptera Triozidae) 3. Mating, fertility and oviposition. Phytophylactica 23:195–200.
- van den Berg MA, Deacon VE, Thomas CD. 1991b. Ecology of the citrus psylla *Trioza erytrae* (Hemiptera, Triozidae) 4. Settling and general behaviour of nymphs. Phytophylactica 23:201–206.
- van den Berg MA, de Villiers EA. 1987. Psyllids, aphids and whiteflies. Bull Dep Agri Water Supply Repub S Afr. 411:43–48.
- van den Berg MA, van Vuuren SP, Deacon VE. 1987. Cross-breeding and greening disease transmission of different populations of the citrus psylla *Trioza erytrae* (Hemiptera: Triozidae). Phytophylactica 19:353–354.
- van Klinken RD. 2000. Host-specificity constrains evolutionary host change in the psyllid *Prosopidopsylla flava*. Ecol Entomol. 25:413–422.



- van Vuuren SP, Moll JN. 1984. Population dynamics and greening transmission by the psyllid *Trioza erytrae* (Del Guercio). In: Proceedings of the greening symposium, Citrus & Subtropical Fruit Research Institute, Nelspruit, p. 90–94.
- Verrier ML. 1929. Contribution à l'étude de la cecidie de *Livia juncorum* Latr. (Hem Psyllidae) sur *Juncus conglomeratus* L. Bull Soc Entomol Fr. 19:77–80.
- Vosseler J. 1906. Eine Psyllide als Erzeugerin von Gallen am Mwulebaum (*Chlorophora excelsa* (Welw.) Benth et Hook). Z Wiss Insectenbiol. 2:276–285 and 305–316.
- Waku Y, Endo Y. 1987. Ultrastructure and life cycle of the symbionts in a Homopteran Insect *Anomoneura mori* Schwartz (Psyllidae). Appl Entomol Zool. 22:630–637.
- Wallis RL. 1946. Seasonal occurrence of the potato psyllid in the North Platte Valley. J Econ Entomol. 39:689–694.
- Wallis RL. 1955. Ecological studies on the potato psyllid as a pest of potatoes. Tech Bull US Dep Agri. 1107:1–24.
- Walton BCJ. 1944. The biology of *Pachypsylla celtis-gemma* Riley (Homoptera: Psyllidae) and the relationship of the parasite to the bud of *Celtis occidentalis* [doctoral thesis]. [New York]: Fordham University.
- Walton BCJ. 1960. The life cycle of the hackberry gall-former *Pachypsylla celtidis-gemma* (Homoptera: Psyllidae). Ann Entomol Soc Am. 53:265–277.
- Watmough RH. 1968a. Notes on the biology of *Artytaina spartiophila* and *Artytaina genistae* (Homoptera, Psyllidae) on broom *Sarothamnus scoparius*. J Entomol Soc South Afr. 31:115–122.
- Watmough RH. 1968b. Population studies on two species of Psyllidae (Homoptera: Sternorrhyncha) on broom *Sarothamnus scoparius*. J Anim Ecol. 37:283–314.
- Webb JW. 1977. The life history and population dynamics of *Acizzia russellae* (Homoptera, Psyllidae). J Entomol Soc South Afr. 40:37–46.
- Webb JW, Moran VC. 1978. Influence of host plant on the population dynamics of *Acizzia russellae* (Homoptera Psyllidae). Ecol Entomol. 3:313–321.
- Weintraub PG, Beanland L. 2006. Insect vectors of phytoplasmas. Annu Rev Entomol. 51:91–111.
- Weiss HB. 1917. The bay flea-louse, *Trioza alacris* Flor, as a new pest in New Jersey. Can Entomol. 49:73–75.
- Weiss HB. 1921. Notes on the life history of *Pachypsylla celtidis gemma* Riley. Can Entomol. 53:19–21.
- Weiss HB, Dickerson EL. 1921. Notes on *Trioza alacris* Flor in New Jersey. Psyche 25:59–63.
- Weiss HB, Nicolay AS. 1918. The life history and early stages of *Calophya nigripennis*. J Econ Entomol. 11:467–471.
- Weiss HB, West E. 1922. Notes on *Livia maculipennis* (Fitch) (Homoptera: Chermidae). Psyche 29:226–229.
- Westgard PH, Westwood MN, Lombard PB. 1970. Host preference and resistance of *Pyrus* species to the pear psylla, *Psylla pyricola* Foerster. J Am Soc Horti. 95:34–36.
- Wheeler AG. 1994. *Craspedolepta eas*: distribution, host, and habits of a phlox specialist (Homoptera: Psylloidea: Aphalaridae). Proc Entomol Soc Wash. 96:91–97.
- Wheeler AG, Rawlins JE. 1993. *Calophya triozmima* Schwarz, a sumac-feeding psyllid new to the eastern United States (Homoptera: Psylloidea: Calophyidae). Proc Entomol Soc Wash. 95:99–106.
- Wheeler GS, Ordnung KM. 2005. Secondary metabolite variation affects the oviposition preference but has little effect on the performance of *Boreioglycaspis metalencae*: a biological control agent of *Melaleuca quinquenervia*. Biol Control. 35:115–123.
- White IM, Hodkinson ID. 1985. Nymphal taxonomy and systematics of the Psylloidea (Homoptera). Bull Brit Mus (Nat Hist.) 50:153–301.
- White MG. 1966. The problems of the *Phytolyma* gall bug in the establishment of *Clorophora*. Inst Pap Commonw For Inst. 37:1–52.

- White MG. 1967. Research in Nigeria on the iroko gall bug (*Phytolyma* sp.) injury to iroko tree (*Chlorophora* sp.). Niger For Inf Bull (New Ser.) 18:1–72.
- White TCR. 1968. Uptake of water by eggs of *Cardiaspina densitexta* (Homoptera, Psyllidae) from leaf of host plant. J Insect Physiol. 14:1669–1683.
- White TCR. 1969. An index to measure weather-induced stress of trees associated with outbreaks of psyllids in Australia. Ecology 50:905–909.
- White TCR. 1970a. Airborne arthropods collected in South Australia with a drogue-net towed by a light aircraft. Pac Insect. 12:251–259.
- White TCR. 1970b. The nymphal stage of *Cardiaspina densitexta* (Homoptera, Psyllidae) on leaves of *Eucalyptus fasciculosa*. Aust J Zool. 18:273–293.
- White TCR. 1970c. Some aspects of the life history, host selection, dispersal and oviposition of adult *Cardiaspina densitexta* (Homoptera, Psyllidae). Aust J Zool. 18:105–117.
- White TCR. 1971. Lerp Insects (Homoptera: Psyllidae) on red gum *Eucalyptus camaldulensis* in South Australia. S Aust Nat. 46:20–23.
- White TCR. 1973. Aerial dispersal of adult *Cardiaspina densitexta* (Homoptera, Psyllidae) in South Australia. Trans R Soc S Aust. 97:29–31.
- Whittaker JB. 1985. Population cycles over a 16-year period in an upland race of *Strophingia ericae* (Homoptera: Psylloidea) on *Calluna vulgaris*. J Anim Ecol. 54:311–322.
- Wilcke J. 1941. Biologie en morphologie van *Psylla buxi*. Tijdschr Plantenzeikten 47:41–89.
- Wilde WHA. 1962. Bionomics of the pear psylla, *Psylla pyricola* Foerster, in pear orchards of the Kootenay Valley of British Columbia 1960. Can Entomol. 94:845–849.
- Wilde WHA. 1965. The pear psylla, *Psylla pyricola* Foerster, in Ontario (Hemiptera: Chermidae): a review. Proc Entomol Soc Ont. 95:5–10.
- Wilde WHA, Watson TK. 1963. Bionomics of the pear psylla, *Psylla pyricola* Foerster, in the Okanagan Valley of British Columbia. Can J Zool. 41:953–961.
- Wilde WHA, Carpenter J, Liberty J, Tunnicliffe J. 1971. *Psylla pyricola* (Hemiptera:Psyllidae) vector relationships with *Erwinia amylovora*. Can Entomol. 103:1175–1178.
- Wille HP. 1950. Untersuchungen uber *Psylla piri* L. und andere Birnblattsaugerarten im Wallis. Eidgenossischen Technischen Hochschule in Zurich: 1–113.
- Williams MW, Benson NR. 1966. Transfer of C14 components from *Psylla pyricola* Foer. to pear seedlings. J Insect Physiol. 12:251–254.
- Williams MW, Batjer LP, Degman ES, Burts EC. 1963. The susceptibility of some pear species to injury from pear psylla. Proc Am Soc Horti Sci. 82:109–113.
- Willson BW, Garcia CA. 1992. Host specificity and biology of *Heteropsylla spinulosa* (Hom, Psyllidae) introduced into Australia and Western-Samoa for the biological control of *Mimosa invisa*. Entomophaga 37:293–299.
- Wineriter SA, Buckingham GR, Frank JH. 2003. Host range of *Boreioglycaspis melaleuciae* Moore (Hemiptera: Psyllidae), a potential biocontrol agent of *Melaleuca quinquenervia* (Cav.) S.T. Blake (Myrtaceae), under quarantine. Biol Control. 27:273–292.
- Wojnarowska P. 1962. *Psylla pyrisuga* Foerst. Red pear psylla. Prace Naukowe Inst Ochrony Roslin 4:153–177.
- Wojnarowska P, Baranowna I, Lipowa I. 1960. *Psylla pyri* L. Prace Naukowe Inst Ochrony Roslin 2:143–161.
- Wong TTY, Madsen HF. 1967. Laboratory and field studies on the seasonal forms of pear psylla in northern California. J Econ Entomol. 60:163–168.
- Woodburn TL, Lewis EE. 1973. A comparative histological study of the effects of feeding by nymphs of four psyllid species on the leaves of eucalypts. J Aust Entomol Soc. 12:134–138.
- Yang MM, Liao LH, Lou MF, Chen WC, Huang SS, Tung GS, Weng YC, Shen CC. 2006. Diversity, biology, and nutritional adaptation of psyllids and their galls in Taiwan. In: Ozaki K, Yukawa J, Ohgushi T, Price PW, editors. Gallling arthropods and their associates: ecology and evolution. Tokyo (Japan): Springer-Verlag Tokyo. p. 33–42.

- Yasuda K, Tsurumachi M. 1988. Seasonal prevalence of leucaena psyllid *Heteropsylla cubana* Crawford (Homoptera: Psyllidae) in relation to temperature in Ishigaki Island. Proc Assoc Plant Prot, Kyushu. 34:208–211.
- Young GR. 2003. Life history, biology, host plants and natural enemies of the lilly pilly psyllid, *Trioza eugeniae* Froggatt (Hemiptera: Triozidae). Aust Entomol. 30:31–38.
- Zhangeri S. 1954. Nota sulla *Trioza urticae* L. Boll Ist Entomol Univ Bologna. 20:257–273.