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THE FOOD PLANTS OF AUSTRALIAN BUTTERFLY LARVAE

D. E. Symon

Department of Agronomy, Waite Agricultural Research Institute,
University of Adelaide, Glen Osmond, South Australia 5064

Abstract

An examination of the food plants of butterfly larvae of Australia shows that these plants belong mainly to families of tropical origin. Australian or characteristically southern plant families provide food for the larvae of very few species of butterflies. The evidence suggests that the larval/plant relationships were already well established by the time Australia received its butterfly fauna from the north and that few species have been able to transfer freely to food plants in new families.

Introduction

There has been, in recent years, increasing interest in the relationships between butterflies and their food plants. This was described broadly by Ehrlich and Raven (1964) and some aspects of co-evolution by Edgar, Culvenor and Pliske (1974) and Rathcke and Poole (1975). The paper by Ehrlich and Raven (1964) (hereafter E & R (1964)), did not include the insect family Hesperiidae and made very few direct references to Australia.

Two recent books on Australian butterflies, Common and Waterhouse (1972) and Fisher (1978) provide classified lists of the food plants eaten by the caterpillars of these insects. The following analyses are based on this information. So that the data can be presented compactly, both plants and insects are considered at the generic level, although this inevitably obscures some of the specificity of their relationships. The flowers visited by the adult insects are not considered. The term butterfly is as used by Common and Waterhouse (1972) and here includes the superfamilies Hesperioidea and Papilionoidea.

The basic data follow in extended Tables. The arrangement of the butterfly genera follows Common and Waterhouse (1972). The plant genera used as food by butterfly larvae in Australia are extracted from that book, from Fisher (1978), Sankowsky (1978) and from additional data supplied by Dr I.F.B. Common and R.H. Fisher. Alien genera established in Australia are indicated by an asterisk.

Table 1. Superfamily Hesperioidea, Family Hesperiidae, Subfamily Coeliadinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Allora	2	2	—
Hasora	27	4	*Derris*, *Millettia*, *Mucuna*, *Pongamia* (Fab.)
Badamia	2	1	*Terminalia* (Combret.)

This group is too small for any generalisations to be made.

Table 2. Superfamily Hesperioidea, Family Hesperiidae, Subfamily Pyrginae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Euschemon	1	1	*Tetrasynandra*, *Wilkiea* (Monim.); *Tristania* (Myrt.)
Chaetocneme	12	4	*Acmena*, *Tristania* (Myrt.); **Annona* (Annon.); *Cinnamomum* (Laur.)
Netrocoryne	2	1	*Acmena*, *Tristania* (Myrt.); *Alectryon* (Sapin.); *Callicoma* (Cunon.); *Elaeocarpus* (Elaeocarp.); *Endiandra* (Laur.); *Notelaea* (Olea.); *Podocarpus* (Podoc.); *Scolopia* (Flacourt.); *Brachychiton* (Stercul.)
Tagiades	12	2	—
Exometoeca	1	1	—

No particular pattern is evident here and a wide range of tropical and subtropical trees is eaten. The list includes the only record of butterfly larvae on an Australian conifer, *Podocarpus*.

Table 3. Superfamily Hesperioidea, Family Hesperiidae, Subfamily Trapezitinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Rachelia	1	1	—
Trapezites	12	12	*Lomandra* (Xanthor.)
Anisyntoides	1	1	*Acanthocarpus* (Xanthor.)
Anisynta	6	6	**Brachypodium*, *Cynodon*, *Danthonia*, *Poa*, *Stipa* (Poac.)
Dispar	1	1	*Poa* (Poac.); *Lomandra* (Xanthor.)
Pasma	1	1	*Poa*, *Tetrarrhena* (Poac.)
Signeta	2	2	*Poa* (Poac.)
Toxidia	9	8	*Cenchrus*, *Tetrarrhena* (Poac.); *Gahnia* (Cyp.); *Dianella* (Lil.)
Neohesperilla	4	4	—
Hesperilla	14	14	*Baumea*, *Carex*, *Cyperus*, *Gahnia*, *Scleria* (Cyp.)
Oreisplanus	2	2	*Carex*, *Gahnia*, *Scirpus* (Cyp.)
Motasingha	2	2	*Gahnia*, *Lepidosperma* (Cyp.)
Mesodina	2	2	*Patersonia* (Irid.)
Proeidosa	1	1	*Triodia* (Poac.)
Croitana	1	1	—

This is described as a "characteristically Australian subfamily" and most species are confined to Australia. It can be seen that this subfamily feeds exclusively on monocotyledons of several families in which the grasses and sedges are almost equally common. The grass genera *Poa* and *Stipa* could be considered cosmopolitan, *Tetrarrhena* is southern and the sedge genera range into the tropics, e.g. *Gahnia*, or are cosmopolitan (*Carex* and *Cyperus*). The list includes the only larvae in Australia feeding on a member of the Iridaceae.

Table 4. Superfamily Hesperioidea, Family Hesperiidae, Subfamily Hesperiinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Notocrypta	10	1	*Alpinia*, *Hornstedtia* (Zingib.)
Taractrocera	14	5	*Carex* (Cyp.); *Brachiaria*, *Cenchrus*, *Cynodon*, *Danthonia*, *Echinopogon*, *Imperata*, *Microlaena*, *Oryza*, *Pennisetum*, *Paspalum*, *Poa* (Poac.)
Ocybadistes	5	4	**Brachypodium*, *Cynodon*, *Pennisetum* (Poac.); *Thuarea* (Cyp.); *Dianella* (Lil.)
Suniana	3	2	*Imperata*, *Leersia*, *Panicum*, *Paspalum* (Poac.)
Oriens	8	1	—
Arrhenes	7	2	*Imperata*, *Leersia*, **Saccharum* (Poac.)
Telicota	22	9	*Imperata*, *Leptaspis*, *Oryza*, *Sorghum* (Poac.); *Flagellaria* (Flagell.); *Scleria* (Cyp.)
Cephrenes	5	2	*Archontophoenix*, *Cocos*, *Livistona* (Palm.)
Sabera	11	3	*Cordyline* (Lil.)
Mimene	15	1	—
Parnara	4	2	*Bambusa*, *Oryza*, **Saccharum* (Poac.); *Colocasia* (Arac.)
Borbo	18	3	*Oryza*, *Paspalum*, **Saccharum* (Poac.)
Pelopidas	9	2	*Oryza*, *Paspalum*, *Sorghum*, **Saccharum* (Poac.)

This extensive tropical subfamily feeds exclusively on species of monocotyledons of several families, and includes the principal feeder on palms, *Cephrenes*. The grasses are almost all coarse-leaved tropical species. *Taractrocera* includes the more southern *Microlaena*, *Danthonia* and *Echinopogon* in its diet.

Table 5. Superfamily Papilionoidea, Family Papilionidae, Subfamily Papilioninae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Protographium	1	1	*Rauwenhoffia* (Anon.)
Graphium	numerous	6	**Annona*, *Melodorum*, *Mitrephora*, *Polyalthia*, *Rauwenhoffia*, *Saccopetalum*, *Uvaria*, **Xylopia* (Annon.); *Macaranga* (Euphor.); *Cinnamomum*, *Cryptocarya*, *Endiandra*, *Litsea*,, *Neolitsea* (Laur.); **Michelia* (Magnol.); *Atherosperma*, *Daphnandra*, *Doryphora* (Monim.); *Tristania* (Myrt.); *Geijera* (Rut.); *Diploglottis* (Sapind.); *Planchonella* (Sapot.); *Drimys* (Winter.)
Papilio	numerous	7	*Acronychia*, **Choisya*, **Citrus*, *Clausena*, *Eremocitrus*, *Eriostemon*, *Euodia*, *Fagara*, **Feronia*, *Flindersia*, *Geijera*, *Glycosmis*, *Halfordia*, *Melicope*, *Microcitrus*, *Micromelum*, *Murraya*, *Phebalium*, *Zanthoxylum*, *Zieria* (Rutac.); *Psoralea* (Fab.); *Cryptocarya* (Laur.); *Morinda* (Rub.)
Cressida	1	1	*Aristolochia* (Aristo.)
Pachliopta	13	1	*Aristolochia* (Aristo.)
Ornithoptera	12	1	*Aristolochia* (Aristo.)

Three genera are confined to *Aristolochia*; *Papilio* eats plants of no fewer than 20 genera belonging to the Rutaceae, while *Graphium* and *Protographium* consume leaves of a wide variety of tropical trees (23 genera) of which the Annonaceae, Lauraceae and Monimiaceae are prominent. The families listed are similar to those given by E & R (1964). However, the Umbelliferae (Apiaceae) listed by E & R (1964) as extra tropical food plants for some members of the Papilionidae have not been recorded in Australia.

Table 6. Superfamily Papilionoidea, Family Pieridae, Subfamily Coliadinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Catopsilia	numerous	4	*Cassia* (Caesal.)
Eurema	numerous	8	*Acacia*, *Albizia*, **Leucaena*, *Neptunia* (Mimos.); *Cassia* (Caesal.); *Indigofera*, *Sesbania* (Fab.); *Breynia*, *Phyllanthus* (Euph.)

This subfamily, well developed in the tropics, is found mainly in northern Australia and eats shrubby legumes, all with pinnate leaves, and two genera of Euphorbiaceae. This is a somewhat more narrowly based list than that given by E & R (1964) who note that the legumes are the most important food plants of the Coliadinae.

Table 7. Superfamily Papilionoidea, Family Pieridae, Subfamily Pierinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Elodina	5	4	*Capparis* (Capparid.)
Delias	150	8	*Exocarpos*, *Santalum* (Santal.); *Amyema*, *Dendrophthoe*, *Korthalsella*, *Muellerina* (Loranth.)
Anaphaeis	9	1	*Apophyllum*, *Capparis* (Capparid.)
Cepora	20	1	*Capparis* (Capparid.)
Appias	30	5	*Drypetes* (Euph.)
Pieris	numerous	1	**Brassica*, **Cakile*, *Lepidium* (Brassic.); *Cleome* (Capparid.); **Reseda* (Resed.); **Tropaeolum* (Tropaeol.)

There is considerable specialisation in this subfamily. The introduced *Pieris* mainly eats members of Brassicaceae (Cruciferae), all introduced with the exception of *Lepidium*. Species of two other genera eaten, *Reseda* and *Cleome* belong to the Resedaceae and Capparidaceae respectively and all these are grouped in the plant order Capparidales; *Tropaeolum* is not closely related. The three genera *Elodina*, *Anaphaeis*, and *Cepora* eat only species of *Capparis* and *Apophyllum*, the latter also in the Capparidaceae. An exception is *Appias* on *Drypetes* (Euphorbiaceae). The largest genus *Delias* is found on Loranthaceae and Santalaceae, two related families in the order Santalales and not close to Capparidales. The plant genera eaten agree closely with those given by E & R (1964).

Table 8. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Danainae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Danaus	40	6	**Araujia*, **Asclepias*, **Calotropis*, *Cynanchum*, *Leichhardtia*, *Pentatropis*, *Secamone* (Asclep.)
Euploea	40	10	**Asclepias*, *Cryptostegia*, *Cynanchum*, *Gymnanthera*, *Hoya*, *Leichhardtia*, *Sarcostemma*, *Secamone* (Asclep.); *Carissa*, **Mandevillea*, **Nerium*, *Parsonsia*, **Stephanotis*, **Trachelospermum* (Apocyn.); *Ficus*, *Malaisia* (Morac.)

With the exception of the two plant genera belonging to the Moraceae, the Danainae feed only on species of Asclepiadaceae and Apocynaceae, two closely related families. However, all three families have milky sap and the last two contain many species with tissues toxic to higher animals. The plants eaten in Australia differ in no way from the list given for the subfamily by E & R (1964). There has been considerable study of the relationships of these butterfly genera and their food plants, Edgar, Culvenor and Pliske (1974).

Table 9. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Ithomiinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Tellervo	1	1	*Parsonsia* (Apocyn.)

This subfamily is primarily American and only one species is recorded for Australia from Cape York. In the Americas the subfamily feeds exclusively on many genera of Solanaceae (E & R 1964). The co-evolution there of butterfly and plant is described by Rathcke and Poole (1975). It is of much interest that no butterfly larvae have been recorded from Australian species belonging to the Solanaceae. The genus *Solanum* is widespread and half a dozen other genera belonging to the Solanaceae occur in Australia. The diet of *Tellervo* is exceptional in the subfamily.

Table 10. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Satyrinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Melanitis	13	2	*Imperata*, *Paspalum*, **Saccharum*, **Stenotaphrum* (Poac.)
Elymnias	40	1	—
Mycalesis	numerous	3	*Imperata* (Poac.)
Orsotriaena	2	1	—
Hypocysta	12	6	*Cynodon*, *Imperata* (Poac.)
Argynnina	2	2	**Lolium* (Poac.)
Geitoneura	3	3	**Brachypodium*, *Poa*, *Themeda* (Poac.)
Heteronympha	7	7	**Brachypodium*, *Danthonia*, *Poa*, *Themeda* (Poac.); *Carex* (Cyp.)
Nesoxenica	1	1	*Uncinia* (Cyp.)
Oreixenica	6	6	*Microlaena*, *Poa* (Poac.)
Tisiphone	2	2	*Imperata* (Poac.); *Gahnia* (Cyp.)
Xois	2	1	*Imperata* (Poac.)

This subfamily contains a distinctly Australian element of endemic and southern genera. It feeds exclusively on monocotyledons, which include three sedges, but mainly on coarse-leaved tropical grasses. E & R (1964) record Juncaceae and Restionaceae as occasionally eaten but both are conspicuously absent from Australian food plant lists.

Table 11. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Morphinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Taenaris	20	2	No record of food plants from Australia is given.

E & R (1964) state that eleven genera feed on monocotyledons and that *Morpho* feeds on dicotyledons.

Table 12. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Charaxinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Polyura	numerous	1	*Abarema*, *Acacia*, *Albizia* (Mimos.); *Caesalpinia*, *Cassia*, **Delonix* (Caesal.); **Robinia* (Fab.); *Guilfoylia* (Simarub.); *Brachychiton* (Stercul.); *Celtis* (Ulm.); *Cinnamomum* (Laur.); **Lagerstroemia* (Lythr.)

A polyphagous species found on woody tropical legumes and on four unrelated genera of tropical trees. Small as this sample is of the subfamily, it does not differ from the food lists given by E & R (1964).

Table 13. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Nymphalinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Phaedyma	1	1	*Mucuna*, *Pongamia* (Fab.); *Aphananthe*, *Celtis* (Ulm.); *Ehretia* (Borag.); *Bombax*, *Brachychiton* (Stercul.)
Neptis	several	1	—
Pantoporia	14	2	*Derris*, *Lonchocarpus* (Fab.)
Argyreus	1	1	*Viola* (Viol.)
Mynes	6	1	*Dendrocnide*, *Pipturus* (Urtic.)
Doleschallia	9	1	*Asystasia*, *Graptophyllum*, *Pseuderanthemum*, *Strobilanthes* (Acanth.)
Hypolimnas	numerous	4	*Alternanthera* (Amaran.); *Sida* (Malv.); *Polygonum* (Polygon.); *Richardia* (Rub.); **Synedrella* (Ast.); *Portulaca* (Portul.); *Asystasia*, *Dipteracanthus*, *Graptophyllum*, *Pseuderanthemum* (Acanth.)
Yoma	1	1	—
Vanessa	numerous	3	*Ammobium*, **Arctotheca*, **Artemisia*, *Gnaphalium*, *Helichrysum*, *Helipterum*, **Onopordum* (Ast.); **Helxine*, *Urtica* (Urtic.)
Junonia	numerous	3	*Asystasia*, *Hemigraphis*, *Hygrophila*, *Pseuderanthemum*, *Thunbergia* (Acanth.); *Epaltes* (Ast.); *Evolvulus* (Convol.); *Goodenia*, *Scaevola* (Good.); *Plantago* (Plantag.); *Centaurium* (Gentian.); *Portulaca* (Portul.); **Antirrhinum*, **Angelonia*, *Buchnera*, **Russelia* (Scroph.); *Verbena* (Verben.)
Cethosia	12	2	*Adenia* (Passifl.)
Vindula	4	1	*Adenia*, *Passiflora* (Passifl.)
Vagrans	1	1	*Homalium*, *Xylosma* (Flacourt.)
Phalanta	several	1	*Petalostigma* (Euph.)
Cupha	10	1	*Flacourtia*, *Scolopia*, *Xylosma* (Flacourt.)

The species of this subfamily eat very varied food plants. *Cethosia* and *Vindula* on Passifloraceae, *Vagrans* and *Cupha* on Flacourtiaceae, which together with *Viola* are grouped in the Violales and considered close (as orders go) to the Passiflorales. *Vanessa* is one of the few genera feeding on the very large cosmopolitan family Asteraceae (Compositae). The polyphagous *Junonia* feeds on a number of genera grouped in the order Scrophulariales, and in fact *Vanessa* and *Junonia* eat more of the 'advanced' plant genera than any other two butterfly genera in Australia. It can be noted that few legumes and no monocotyledons are eaten.

Table 14. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Acraeinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Acraea	12	1	*Adenia*, *Passiflora*, *Tacsonia* (Passifl.)

This subfamily is closely related to the Nymphalinae and does not differ in food plants eaten. The single species established in Australia is relatively widespread, but its food plants do not include several families listed by E & R (1964).

Table 15. Superfamily Papilionoidea, Family Nymphalidae, Subfamily Libytheidae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Libythea	12	1	No record of food plant from Australia

This genus is restricted in its distribution in Australia to Cape York and the far north coast of W. Australia and the Northern Territory. It's larvae are reported by E & R (1964) to feed almost exclusively on *Celtis* with a few records on *Prunus*.

Table 16. Superfamily Papilionoidea, Family Lycaenidae, Subfamily Lycaeninae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Liphyra	2	1	—
Bindahara	2	1	*Salacia* (Celast.)
Rapala	numerous	1	*Alphitonia*, *Ziziphus* (Rham.); **Litchi* (Sapind.)
Virachola	numerous	2	*Strychnos* (Logan.)
Deudorix	numerous	2	*Caryota* (Palm.); *Macadamia* (Prot.); *Harpullia* (Sapind.)
Hypolycaena	numerous	1	*Vanda*, *Dendrobium* (Orchid.); *Flagellaria* (Flag.); *Cassia* (Caesal.); *Acmena* (Myrt.); *Cupaniopsis* (Sapind.); *Planchonella* (Sapot.); *Clerodendrum*, *Faradaya* (Verben.)
Pseudalmenus	1	1	*Acacia* (Mimos.)
Jalmenus	9	9	*Acacia* (Mimos.); *Cassia* (Caesal.); *Heterodendrum* (Sapind.); *Eucalyptus* (Myrt.)
Narathura	150	4	*Acmena*, *Eucalyptus*, *Melaleuca* (Myrt.) *Cordia* (Borag.); *Cryptocarya* (Laur.); *Cupaniopsis* (Sapind.); *Glochidion* (Euph.); *Faradaya* (Verben.); *Heritiera* (Stercul.); *Hibiscus* (Malv.); *Terminalia* (Combret.)
Ogyris	15	12	*Amyema*, *Amylotheca*, *Dendrophthoe*, *Lysiana*, *Muellerina* (Loranth.); *Choretrum*, *Leptomeria* (Santal.)
Hypochrysops	numerous	17	*Drynaria* (Pterido.-Polypod.); *Cassinia* (Ast.); *Barringtonia* (Barring.); *Casuarina* (Casuar.); *Terminalia* (Combret.); *Elaeocarpus* (Elaeoc.); *Brachyloma* (Epac.); *Jacksonia* (Fab.); *Amyema*, *Dendrophthoe*, *Muellerina* (Loranth.); *Acacia* (Mimos.); *Angophora*, *Eucalyptus* (Myrt.); *Banksia* (Prot.); *Alphitonia*, *Pomaderris* (Rham.); *Bruigiera*, *Ceriops*, *Rhizophora* (Rhizoph.); **Prunus*, *Rubus* (Ros.); *Myrmecodia* (Rub.); *Choretrum*, *Exocarpos* (Santal.); *Cupaniopsis*, *Dodonaea*, *Heterodendrum* (Sapind.); *Smilax* (Smilac.); *Commersonia* (Stercul.); **Camellia* (Thea.); *Triumfetta* (Tilia.); *Avicennia* (Verb.)

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Table 16 (*continued*)

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Pseudodipas	7	6	*Smilax* (Smilac.); *Diospyros* (Eben.); *Clerodendrum*, *Faradaya* (Verben.)
Paralucia	3	3	*Bursaria*, *Citriobatus* (Pittosp.)
Lucia	1	1	*Oxalis* (Oxal.)
Danis	several	3	*Alphitonia* (Rham.); *Entada* (Mimos.)
Petrelaea	1	1	—
Prosotas	18	3	*Acacia* (Mimos.); *Macadamia* (Prot.); *Alectryon*, *Cupaniopsis*, **Litchi* (Sapind.)
Nacaduba	37	4	*Acacia* (Mimos.); *Aegiceras*, *Maesa*, *Rapanea* (Myrsin.); *Alectryon*, *Cupaniopsis*, *Heterodendrum* (Sapind.); *Macadamia* (Prot.)
Ionolyce	2	1	—
Erysichton	3	2	*Alectryon*, *Cupaniopsis* (Sapind.); *Ehretia* (Borag.); *Macadamia* (Prot.); *Dendrophthoe* (Loranth.)
Catopyrops	4	2	*Caesalpinia* (Caesal.); *Trema* (Ulm.)
Jamides	numerous	5	*Canavalia*, **Phaseolus* (Fab.); *Sarcopteryx* (Sapind.)
Syntarucus	several	1	*Plumbago* (Plumb.)
Anthene	several	2	*Caesalpinia*, *Cassia* (Caesal.); *Pongamia* (Fab.); *Clerodendrum*, *Faradaya* (Verben.); *Cupaniopsis*, **Litchi* (Sapind.)
Theclinesthes	7	7	*Cycas*, *Macrozamia* (Cycad.); *Arthrocnemum*, *Atriplex*, *Chenopodium*, *Rhagodia*, *Salicornia* (Chenopod.); *Adriana* (Euph.); *Sesbania* (Fab.); *Acacia* (Mimos.); *Eucalyptus* (Myrt.); *Alectryon*, *Atalaya*, *Cupaniopsis* (Sapind.)
Lampides	1	1	**Chamaecytisus*, *Clianthus*, *Crotalaria*, **Cytisus*, *Dolichos*, *Kennedia*, **Lathyrus*, *Lotus*, **Lupinus*, **Phaseolus*, **Pisum*, *Psoralea*, *Sesbania*, *Swainsona*, **Vicia*, **Virgilia* (Fab.)
Catochrysops	3	2	*Crotalaria* (Fab.)
Euchrysops	numerous	1	*Phaseolus*, *Sesbania*, *Vigna* (Fab.)
Everes	several	1	—
Neolucia	3	3	*Aotus*, *Bossiaea*, *Daviesia*, *Dillwynia*, *Eutaxia*, *Pultenaea* (Fab.); *Epacris*, *Monotoca* (Epacrid.)
Zetona	1	1	—
Zizula	2	1	—
Zizina	3	1	*Desmodium*, *Glycine*, *Indigofera*, *Lotus*, **Medicago*, **Phaseolus*, **Pisum*, *Psoralea*, *Swainsona*, **Trifolium*, *Trigonella*, **Vicia*, **Virgilia* (Fab.)
Zizeeria	2	1	*Glinus* (Aizoac.); *Tribulus* (Zygoph.)
Famegana	1	1	(Fabaceae)
Freyeria	few	1	*Indigofera* (Fab.)
Candalides	numerous	2	*Tieghemopanax* (Aral.); *Cassia* (Caesal.); *Castanospermum*, *Jacksonia*, *Millettia*, **Wisteria* (Fab.); *Flagellaria* (Flagell.); *Westringia* (Lam.); *Cassytha*, *Cryptocarya* (Laur.); *Amyema*, *Amylotheca*, *Benthamina*, *Dendrophthoe*, *Muellerina* (Loranth.); *Eremophila*, *Myoporum* (Myop.); *Plantago* (Plantag.); *Grevillea*, *Macadamia* (Prot.); *Alectryon*, *Cupaniopsis* (Sapind.); *Parahebe* (Scroph.); *Brachychiton* (Stercul.); *Pimelea* (Thymel.)

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Table 16 (*continued*)

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Nesolycaena	1	1	*Boronia* (Rut.)
Adaluma	1	1	*Boronia* (Rut.)
Philiris	numerous	6	*Ficus* (Mor.); *Glochidion* (Euph.)
Lycaenopsis	1	1	—
Megisba	2	1	—
Neopithecops	several	1	*Glycosmis* (Rut.)
Pithecops	4	1	—

This large subfamily includes 44 genera and 119 species in Australia. The larvae eat a variety of plants but there are several specialised genera of note. *Ogyris* species are confined to Loranthaceae and Santalaceae; *Paralucia* is the only genus found on the Pittosporaceae; *Lucia* on *Oxalis*; and *Theclinesthes* the only genus found on Chenopodiaceae; *Neolucia* is one of the few genera the larvae of species of which eat the typically Australian leguminous genera such as *Daviesia*, *Eutaxia*, *Pultenaea*. The genera *Lampides* and *Zizina* comprise species the larvae of which attack a number of the introduced legumes e.g., *Vicia*, *Pisum* and *Trifolium*, as well as native genera. *Theclinesthes* is the only genus the larvae of which eat the primitive gymnosperms *Cycas* and *Macrozamia*. The subfamily also includes the two genera comprising species with the widest larval food ranges recorded in Australia, *Hypochrysops* eating species of 33 genera and *Candalides* 25 genera. These two butterfly genera both contain species the larvae of which eat species of plant genera from the Loranthaceae, legumes and Sapindaceae, in addition to many broad-leaved trees. The occasional records of *Eucalyptus*, *Banksia*, *Grevillea* and *Casuarina* represent members of the southern elements in our Flora. Although not detailed here the Lycaenidae also includes several genera which have specialised relationships with ants; E & R (1964) consider that this might influence the food plants eaten. The butterfly genera in Australia do not include the lichen-eaters known in Africa, but do include some which feed on cycads and on orchids both of which have been recorded as food plants for overseas genera, but not those from southern Africa.

Table 17. Superfamily Papilionoidea, Family Lycaenidae, Subfamily Nemeobiinae.

Butterfly genera	Total no. of species in genus	No. of species in Australia	Food plants in Australia
Praetaxila	10	1	No record of food plants from Australia

Table 18. Condensed summary of food plants of Australian butterfly larvae.

Families and subfamilies	Food plants
Hesperiidae	
Coeliadinae	Varied incl. legumes
Pyrginae	Varied trop. trees
Trapezitinae	Monocotyledons
Hesperiinae	Monocotyledons
Papilionidae	
Papilioninae	Tropical trees, many Rutaceae, *Aristolochia*
Pieridae	
Coliadinae	Woody legumes
Pierinae	Santales, Capparidaceae, Brassicaceae, Tropaeolaceae

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Table 18 (*continued*)

Families and subfamilies	Food plants
Nymphalidae	
Danainae	Asclepiadaceae, Apocynaceae
Ithomiinae	Apocynaceae
Satyrinae	Monocotyledons
Morphinae	—
Charaxinae	Varied incl. legumes
Nymphalinae	Very varied, more herbaceous species, no monocotyledons
Acraeinae	Passifloraceae
Libytheidae	No information from Australia
Lycaenidae	
Lycaeninae	Very varied (very few monocots)
Nemeobiinae	No information

Entomological considerations

It is obvious that within some families, subfamilies or genera of butterflies there is a remarkable degree of canalisation tying the butterfly larvae to particular food plants (Table 18). This is based overwhelmingly on the chemistry of the plants rather than on their morphology. I do not think that there is any evidence that the plants obtain any advantage from being eaten despite Culvenor's (1970) statement that the Poaceae (Gramineae) is the only plant family adapted to being eaten, or at least resistant to being torn up and totally consumed. This is in marked contrast to the relationships between insects and the plants that they pollinate. There are numerous morphological defence responses that protect plants to a varying extent against predation e.g., dense tomentum, glandular hairs, resins and prickles. The development of chemically active secondary substances in the plant that disturb the metabolism of the predator are less obvious defence mechanisms (Culvenor 1970). The following examples are culled from Fraenkel (1969). There may be repellent volatile chemicals from the plants which reduce any stimulation for feeding or egg laying, or the plants may contain a "juvenile hormone activity" which prevents the process of insect metamorphosis. Plants may also contain a "moulting hormone activity" which stimulates the processes which lead to the critical phenomenon of moulting. A combination of one or more of these may protect the plants against susceptible larvae.

What, then, are the nature of the ties which link some butterfly larvae so strongly to particular genera or families of plants in so many cases?

1. Some larvae sequester toxic substances from the food plants which then make the larvae or adult butterflies unpalatable to predators. The well-known examples are the Monarch Butterfly which feeds on genera of the Asclepiadaceae and related butterfly genera which eat plants of the Apocynaceae or Aristolochiaceae. Plants in these families contain cardiac glycosides many of which are toxic to higher animals. The defence agent for the plant becomes the defence agent for the insect. If these larvae eat other plants, (and this can be induced under experimental conditions), they may cease to be toxic to predators and may then be eaten with impunity. Many of these adult butterflies are conspicuous and showy and have many mimics, Edgar, Culvenor, Pliske (1974).

2. Other butterflies are attracted by particular plant odours which stimulate egglaying, or feeding responses of the larvae. A well known example is the stimulating effect of

mustard oil glycosides in the Brassicaceae on *Pieris*. Similar chemicals are found in the Capparidaceae, Apiaceae and Tropaeolaceae which all provide food plants for Pierids. Once canalised by feeding or egglaying responses to particular plants it is obviously difficult for an insect to transfer to another food plant if vital responses are not triggered.

3. It is now well known that mates may be attracted, or reproductive cycles initiated by an array of chemical substances referred to as pheromones released in the air at extreme dilutions. Precursors for the pheromones are obtained from specific plants e.g., pyrrolizin alkaloids from the Boraginaceae and Asteraceae. Some butterflies have become dependent on these hepatotoxic products for the synthesis of their pheromones. It has been shown that butterflies raised in captivity in the absence of appropriate plant sources are unable to produce the ketones needed, Schneider *et al.*, (1975).

Much of the work in this field is very recent and the use of plants as sources of pheromone precursors is probably far more widespread than has yet been demonstrated. What factors the monocotyledons have in common and to which the Trapezitinae, Hesperiinae and Satyrinae are tied has not been shown. Culvenor (1970) points out that the Poaceae (Gramineae) are remarkable for the paucity of toxic substances and secondary compounds recorded from them and suggests that they are in fact well adapted to being eaten. This does not explain why three subfamilies of butterflies are confined to monocotyledons and other groups avoid them completely.

Once established it may well be difficult for these butterflies to change their feeding habits. After 3,000 years of domestication the silkworm, a moth not a butterfly, still has a restricted diet of mulberry and it has not been possible to induce the larvae to accept a more 'convenient' diet of cabbage, grass, lucerne, or lettuce on which mortality is high.

Botanical considerations

The plant families that are well represented as larval food plants in Australia (Table 19) include the large monocotyledonous families Poaceae (grasses) and Cyperaceae (sedges), but not Juncaceae, and the genus *Lomandra* in Xanthorrhoeaceae (or Liliaceae), but not *Xanthorrhoea* itself.

The dicotyledonous families well represented include all the legumes, Fabaceae, Mimosaceae, and Caesalpiniaceae, the mistletoes Loranthaceae, closely followed by the Sapindaceae and Lauraceae. These are followed by a fairly long 'tail' with 12 families each feeding 5-8 species of butterfly and 38 families each feeding 1-4 species. The principal families of food plants are of tropical origin.

Table 19. Most favoured food plant families of Australian butterfly larvae.

Plant families	Principal distribution	Butterfly species
Gymnosperms		
Cyadaceae	tropic & subtropic	1
Podocarpaceae	tropic & temperate	1
Monocotyledons		
Poaceae	cosmopolitan	51
Cyperaceae	cosmopolitan	19
Palmae	pantropic	3
Flagellariaceae	tropic old world	3
Smilacaceae	tropic	2
4 other 1 species each		

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Table 19 (*continued*)

Plant families	Principal distribution	Butterfly species
Dicotyledons		
Fabaceae	pantemperate	22
Mimosaceae	pantropic	20
Caesalpiniaceae	paleotropic	12
Loranthaceae	tropic	22
Sapindaceae	tropic	20
Lauraceae	paleotropic	11
Rutaceae	widespread ?southern	8
Myrtaceae		
(Leptospermoideae)	Australia	8
(Myrtoideae)	tropic (America)	4
Verbenaceae	tropic & subtropic	7
Capparidaceae	paleotropic	6
Sterculiaceae	pantropic	6
Annonaceae	paleotropic	6
Moraceae	pantropic	6
Proteaceae	temperate, southern	6
Acanthaceae	pantropic	5
Asclepiadaceae	pantropic	5
Euphorbiaceae	cosmopolitan	5
Rhamnaceae	cosmopolitan	5
Rubiaceae	pantropic	5
Aristolochiaceae	tropic	4
Asteraceae	cosmopolitan	4
Apocynaceae	pantropic	3
Boraginaceae	cosmopolitan	3
Epacridaceae	Australian	3
Flacourtiaceae	pantropic	3
Monimiaceae	tropic & subtropic	3
Passifloraceae	tropic (America)	3
Portulacaceae	temperate (America)	3
Santalaceae	temperate & tropic	3
Scrophulariaceae	cosmopolitan	3
Ulmaceae	tropic & temperate	3
26 families with 1-2 species each		

Table 20. Southern botanical families and their butterfly fauna*.

	Approx. no. genera in Australia	Wide dist. in Australia	Butterfly species
Monocotyledons			
Centrolepidaceae	7	—	0
Haemodoraceae	7	—	0
Hypoxidaceae	5	—	0
Juncaceae	9	W	0
Juncaginaceae	3	—	0
Philesiaceae	3	—	0
Philydraceae	5	—	0
Restionaceae	17	W	0
Xanthorrhoeaceae	8	W	10
Dicotyledons			
Aizoaceae	12	W	1
Araliaceae	13	—	1
Casuarinaceae	1	W	1
Chenopodiaceae	27	W	2
Cunoniaceae	14	—	1
Droseraceae	3	W	0
Dilleniaceae	5	W	0
Elaeocarpaceae	5	—	2
Epacridaceae	28	W	3
Eucryphiaceae	1	—	0
Goodeniaceae	14	W	1
Haloragaceae	7	W	0
Monimiaceae	11	—	3
Myoporaceae	2	W	1
Myrtaceae			
(Leptospermeae)	47	W	8
(Myrtoideae)	6	—	4
Pittosporaceae	9	W	2
Portulacaceae	6	W	3
Proteaceae	38	W	6
Rutaceae	38	W	8
Solanaceae	8	W	0
Stackhousiaceae	2	W	0
Stylidiaceae	5	W	0
Thymelaeaceae	7	W	2
Tremandraceae	3	W	0
Winteraceae	2	—	1
Zygophyllaceae	4	W	1

* Botanical families from Good (1961) to which have been added Juncaceae, Chenopodiaceae and Solanaceae; genera from Burbidge (1963); Juncaceae and Xanthorrhoeaceae as used by Burbidge are disputed groupings, nine of the ten species of butterflies listed here eat *Lomandra*; eleven of the sixty-one species of butterflies listed belong to the polyphagous genera *Candalides* and *Hypochrysops*.

While the grasses and sedges are well represented, three monocotyledonous families poorly represented are the Orchidaceae, Juncaceae and the Restionaceae. The first is a large and diverse family but in Australia feeds only one butterfly. The second is not usually considered a 'southern' family but both Cronquist (1968) and Takhtajan (1969) note its morphological affinities to Restionaceae and Rendle (1956) to *Xanthorrhoea* and *Calectasia*, two endemic Australian genera. The Restionaceae is a small but distinctly southern family somewhat similar to many sedges but it feeds no butterflies here.

The following dicotyledonous families well represented in Australia are eaten by few or no butterfly larvae (Table 20): (1) Casuarinaceae which are found throughout most of Australia. (2) Proteaceae which, while not confined to Australia, is one of the classical southern families. The only butterfly larvae recorded on *Banksia* is the polyphagous *Hypochrysops*. The only other Proteaceous genera eaten are *Macadamia* and *Grevillea* by the polyphagous *Candalides*. It is remarkable that there are no records from the large and diverse genera *Dryandra* and *Hakea*. (3) Chenopodiaceae which are well developed in drier Australia feed two butterflies. (4) Dilleniaceae feed no butterfly larvae, the Zygophyllaceae feed one. (5) Considering their occurrence through the warmer parts of Australia, the Malvaceae feed few. (6) Myrtaceae, abundantly and variously developed in Australia and containing one of the largest and most widespread genera in *Eucalyptus*, are eaten by very few butterfly larvae. (7) Haloragaceae, though not a large family, are widespread and *Haloragis* is not represented as a food plant. (8) Epacridaceae, well developed in Australia, feeds only two species of *Neolucia*. (9) Goodeniaceae widespread in Australia are eaten by the larvae of *Junonia* only.

A number of families in the Sympetalae, particularly the Tubiflorae, and including such families as Boraginaceae, Verbenaceae, Labiatae, Scrophulariaceae, Acanthaceae, Myoporaceae, Plantaginaceae, Rubiaceae and Asteraceae (Compositae) feed remarkably few butterfly larvae in Australia. The last is one of the largest and most widespread of all plant families, but includes only 10 genera that are eaten, of which four are introduced, and seven are eaten by a single species *Vanessa kershawi*. Except for the Myoporaceae none of these families is usually considered to be of southern origin or to have been especially elaborated in Australia. In general terms they are considered to be of northern temperate or tropical origin. Strikingly absent from the food plants in this order are those families of southern origin or elaboration, for example Solanaceae, Goodeniaceae, Stylidiaceae.

It is of interest that the two subfamilies of butterflies considered to be well developed in Australia, the Trapezitinae and to a lesser extent the Satyrinae, feed exclusively on monocotyledons, and in the period of their evolution have not spread on to typically Australian or indeed southern families. The principal families involved, the cosmopolitan Poaceae and Cyperaceae, and pantropic Palmae, are in no way especially or singularly Australian. The absence of larval food plants in the Restionaceae, the most distinctly southern family, and in the Juncaceae is intriguing.

Food plants in relation to the origin or centres of diversity of the butterfly genera.

Most of the genera of butterflies in Australia extend through Papua New Guinea to the South-east Asian land mass, or to the South-west Pacific. A few are well developed in or extend to Africa, Eurasia or the Americas. One of these is *Tagiades* (Hesperiidae), a genus of a dozen species widespread in Asia and extending to Africa and Madagascar. Beyond Australia the larvae feed on Dioscoreaceae (yams) and Roxburghiaceae, but especially on Convolvulaceae. All three families are widespread in the tropics and, though not closely related botanically, all three contain many climbing species.

Three genera of the Hesperiinae, *Parnara*, *Borbo* and *Pelopidas*, also extend to Africa

and Madagascar but their recorded food plants in Australia differ in no way from those of other genera in the subfamily. In the family Pieridae the subfamily Coliadinae is well developed in the tropics of both the Old and the New World. Both genera *Catopsilia* and *Eurema* feed on *Cassia* and other woody legumes. While the legumes are widespread in both Old and New World tropics the genus *Cassia* is particularly well developed in the American tropics.

The subfamily Pierinae contains the genus *Pieris* which is well developed in the northern hemisphere and in north and central America. Its prediliction for Brassicaceae (Cruciferae) is well known and this plant family is distributed primarily in the northern hemisphere, particularly in the cooler regions with fewer species elsewhere. As an alien in the Australian fauna *Pieris* has retained its original food plants and the only native plant recorded as a food plant is *Lepidium hyssopifolium* Desv. which belongs to a cosmopolitan genus.

In the family Nymphalidae, subfamily Danaiinae, the genera *Danaus* and *Euploea* feed mainly on Asclepiadaceae and Apocynaceae—both are pantropical and the Asclepiadaceae are well developed in South America. Both families contain many climbers.

The subfamily Ithomiinae is well developed in Central and South America but is only represented here by a single species feeding on *Parsonsia*. In the Americas members of the subfamily feed on species of the Solanaceae.

In the subfamily Nymphalinae, the genus *Argyreus* which belongs to a group of genera well developed in the Palearctic and Nearctic regions with few species in the southern hemisphere, feeds on *Viola*, a genus best developed in the temperate regions of the northern hemisphere. It has not moved from Australian representatives of that genus. The genus *Vanessa*, world wide and best developed in Palearctic and Nearctic areas, feeds in Australia on Asteraceae (Compositae) and the nettle, *Urtica*. The latter belongs to a primarily tropical family, while the former, though cosmopolitan, is not conspicuous in tropical regions and is best developed in temperate areas. The genus *Acraea* (subfamily Acraeinae), is well developed in Africa and here feeds on *Adenia* and *Passiflora* and while the Passifloraceae, to which both genera belong, is well developed in the Americas, *Adenia* is best developed in Africa.

If any generalisation can be drawn from these examples it is that butterfly species in Australia which might be considered outliers of genera well developed elsewhere, remain feeding on plants no different from those found in the main centres of distribution of the genus and they have not moved on to distinctively Australian plants. However, some geographical differences in food preferences are known. *Papilio demoleus* in Australia and New Guinea, for example feeds mostly on *Psoralea* but sometimes on *Citrus* and *Microcitrus*. In India *Citrus* and other Rutaceae are the usual food plants (Common & Waterhouse, 1972).

It could perhaps be expected that the number of plant genera eaten would be related to the number of butterfly species in the genus. If the number of butterfly species is plotted against the number of plant genera eaten the spread is very wide and what little correlation there may be is provided by the few large polyphagous genera *Papilio*, *Euploea*, *Hypochrysops* and *Candalides*. The correlation coefficient between the number of species in the genus and the number of food plant genera eaten is $r = 0.53$ and that between the number of species in the genus and the number of plant families eaten is $r = 0.42$. These can be considered only moderate correlations and so indicate that there is a tendency for the species in a genus of butterflies to be restricted to a limited range of food plants.

Conclusion

The Australian land mass collided with the east Asian land mass no earlier than late Cainozoic (Veevers and McElhinney 1976), about 25-35 million years ago (Oligocene), and began to receive Laurasian tropical elements of its flora and fauna. Butterflies, often considered to be of tropical origin, moved into Australia with their food plants, for by this time the close relationships between butterfly larvae and food plants had become well established. In some cases butterflies followed their preferred food plants into now extremely arid sites, e.g., *Eurema* on *Cassia*, *Jalmenus* on *Acacia*, or *Ogyris* on *Loranthaceae*, and rarely transferred to other elements of the arid flora e.g., Chenopodiaceae, Myoporaceae or Myrtaceae (Leptospermeae).

Those subfamiles of butterflies with many endemic genera and species in Australia are confined to groups of monocotyledons of tropical origin and few have been able to transfer to typically Australian plant families or genera. Butterfly larvae are conspicuously absent from the recognised southern plant families.

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References

Burbidge, N.T. (1963). 'Dictionary of Australian plant genera'. (Angus & Robertson: Sydney.)
Common, I.F.B. and Waterhouse, D.F. (1972). 'Butterflies of Australia'. (Angus & Robertson: Sydney.)
Cronquist, A. (1968). 'The evolution and classification of flowering plants'. (Nelson Ltd; London.)
Culvenor, C.C.J. (1970). Toxic plants a re-evaluation. *Search* 1: 103-110.
Edgar, J.A., Culvenor, C.C.J. and Pliske, T.E. (1974). Co-evolution of Danaid butterflies and their hosts. *Nature* 250: 646-648.
Ehrlich, P.R. and Raven, P.H. (1964). Butterflies and plants. *Evolution* 18: 586-608.
Fisher, R.H. (1978). 'Butterflies of South Australia'. (Government Printer: Adelaide.)
Fraenkel, G. (1969). Evaluation of our thoughts on secondary plant substances. In: 'Insect and host plant'. J. de Wilde and L.M. Schoonhoven (Eds.) (Wageningen.)
Good, R. (1961). 'Geography of the flowering plants'. (Longman Green & Co.: London.)
Rathcke, B.J. and Poole, R.W. (1975). Co-evolutionary race continues: Butterfly larvae adaptation to plant trichomes. *Science* (Wash. D.C.) 187: 175-176.
Rendle, A.B. (1956). 'The classification of flowering plants'. (Cambridge University Press: Cambridge.)
Sankowsky, G. (1978). Some new food plants for various Queensland butterflies. *Aust. ent. Mag.* 5: 77-79.
Schneider, D., Boppre, M., Schneider, H., Thompson, W.R., Boriack, C.J., Petty, R.L. and Meinwald, J. (1975). A pheromone precursor and its uptake in male *Danaus* butterflies. *J. Compl. Physiol.* 97: 245-256.
Takhtajan, A. (1969). 'Flowering plants: origin and dispersal'. (Oliver & Boyd: Edinburgh.)
Veevers, J.J. and McElhinney, M.W. (1976). The separation of Australia from other Continents. *Earth Science Reviews* 12: 139-159.