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The spatial distribution of rain forest butterflies at three sites in North Queensland, Australia

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ABSTRACT. Surveys of the microhabitat distribution of adult butterfly species were undertaken at three rain forest sites in North Queensland, Australia, encompassing a range of rain forest vegetation types. These surveys found little evidence for a specialist canopy fauna. Most species recorded in the canopy were often seen close to the ground. At all sites, most species were observed at the edge of the rain forest habitat; within the rain forest, more species were observed near the ground than in the canopy.

KEY WORDS: Australia, butterflies, canopy, community, Queensland, rain forest, spatial distribution.

INTRODUCTION

Recent studies of insect communities in rain forests have shown a marked vertical stratification, with much of the total flying insect fauna being restricted to the upper canopy (Holloway 1989, Rees 1983, Sutton 1983, 1989). Indeed, recent suggestions of a massive expansion in our estimate of the Earth's total insect species richness (Erwin 1982), are derived largely from a new appreciation of the enormous diversity and distinctiveness of the fauna found in the high canopy of Neotropical rain forest. However such estimates are by no means widely accepted (Stork 1988, Thomas 1990) and the ensuing debate serves to highlight the need for more information on rain forest canopy fauna.

Documentation of vertical distribution patterns is difficult, time-consuming, and labour-intensive for most taxa. One exception is the butterfly fauna. Adult butterflies are relatively large, mostly diurnal, and can be visually censused by a skilled observer (Pollard 1977). Available studies suggest that the marked vertical stratification and the richness of the rain forest canopy fauna also occurs in the butterflies. Papageorgius (1975) found that the butterfly fauna of Peruvian

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rain forest was vertically stratified, with members of the same Mullerian mimicry ring tending to fly at the same levels. Jackson (1961) demonstrated the existence of a distinctive canopy butterfly fauna from the Mpanga forest in Uganda, including some species not previously recorded, and not occurring at lower levels.

This study uses canopy towers located in North Queensland rain forests to examine whether a similarly distinctive canopy butterfly fauna exists in Australia. The butterfly fauna observed in the canopy is compared with that below the canopy, and with the fauna at ground level on the forest edge.

METHODS

The three sites used in this study are at locations where canopy towers have been erected by the CSIRO Division of Wildlife and Ecology (Tropical Forest Research Centre), in a rainfall seasonality gradient running from the coast at Yarrabah westwards to the interior near Mount Garnet. The coastal site is at Pine Creek (16° 59′ S, 145° 50′ E 60 m elevation) at which the vegetation is a 30 m tall, coastal, moist, mildly seasonal, complex mesophyll vine forest (cf. Webb 1978). The second site is at Curtain Fig (17° 17′ S, 145° 35′ E, 720 m elevation) which comprises a 25 m tall, upland, cool, moist, distinctly seasonal, simple notophyll forest. The inland site is at 40 Mile Scrub (18° 6′ S, 145° 50′ E, 780 m elevation), a 16 m tall, upland, very seasonal, semi-evergreen vine thicket.

Each site was visited for one day during each of the following six periods: 1–3 February 1988, 29 April–1 May 1988, 19–22 June 1988, 25–27 August 1988, 24–27 February 1989 and 13–16 June 1989. Sampling of the butterfly fauna was only carried out when conditions were favourable for adult flight (i.e. a high proportion of sunshine and little wind (Cappuccino & Karieva 1985, Zalucki 1981)). Days in which these conditions did not occur were abandoned.

At each site three areas were sampled: above the canopy (a radius of 10 m in all directions from the top of the tower), the area below the canopy (a radius of 10 m from the base of the tower) and a region of rain forest edge (an area of 30 m by 10 m). In addition at Pine Creek a logging track was included as a further sampling area (30 m by 10 m). In all areas the vertical component of the sample was also 10 m.

Each area was visually sampled for 20 minutes during which time an observer (C. J. Hill) identified all butterfly species encountered by sight or capture. The canopy fauna was sampled using binoculars and individuals were assigned to species, genus, family or unknown as appropriate. Nomenclature used in this paper follows that given in Common & Waterhouse (1981) but includes any recent upgradings which have gained current acceptance (see appendix). The relative abundance of each species was estimated by assigning it to one of five categories (1: 1, 2: 2, 3: 3–5, 4: 6–9, 5: > 10 individuals) at the end of the 20 minute sampling period. Absolute estimates of abundance could not be made because each area was traversed several times during the sampling period and the possibility of recounting individuals could not be dismissed. Each area was

sampled three times (morning, midday and afternoon) on each visit. The final relative abundance for each species (or in some cases higher taxon) was the highest category attained in each area during that particular visit.

RESULTS

The cumulative numbers of species identified for each sampling visit are shown in Figure 1. In each site the discovery of additional species had slowed by the fifth visit and only one additional species was discovered at 40 Mile Scrub on the sixth visit.

Table 1 summarizes the representation of different butterfly families at each study site. Pine Creek was the most species rich site with 67 species of which the majority were Nymphalidae and Hesperiidae. At Curtain Fig 64 species were recorded with the Nymphalidae and Lycaenidae containing the highest percentages. There were 45 species recorded at 40 Mile Scrub with three families (the Nymphalidae, Lycaenidae and Pieridae) containing over 75% of the total number of species. Only four hesperiid species were found at this site.

Most species were recorded at more than one location within a site (Table 2). At Pine Creek 75% of the species were recorded at the rain forest edge but nearly

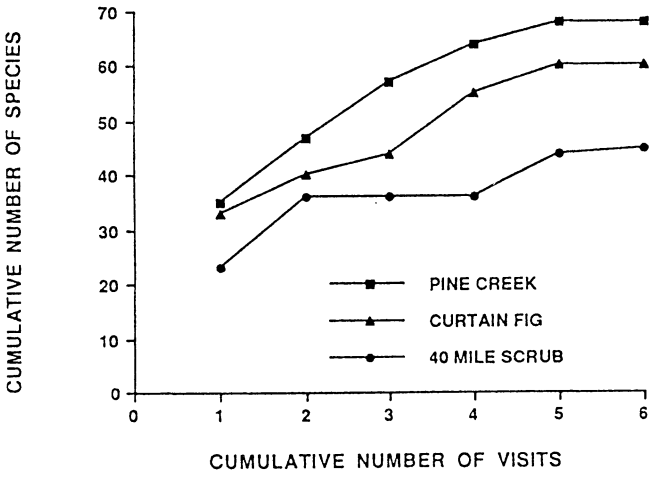

Figure 1. The cumulative number of species recorded at Pine Creek, Curtain Fig and 40 Mile Scrub over six sampling visits.

Table 1. The number (and percentage of the total number) of species of butterfly in each family at Pine Creek(PC), Curtain Fig(CF) and 40 Mile Scrub(40MS).

Site	Papilionidae	Pieridae	Nymphalidae	Lycaenidae	Hesperiidae	Total
PC	7 (10.4)	7 (10.4)	22 (32.8)	11 (16.4)	20 (29.9)	67
CF	9 (14.1)	10 (15.6)	19 (29.7)	14 (21.9)	12 (18.8)	64
40MS	6 (13.3)	11 (24.4)	12 (26.7)	12 (26.7)	4 (8.9)	45

Table 2. The number (and percentage of the total number) of butterfly species which were recorded on the edge, track, ground and canopy at Pine Creek, Curtain Fig and 40 Mile Scrub.

Location	Number of species (percentage of total)		
	Pine Creek	Curtain Fig	40 Mile Scrub
Edge	50 (74.6)	58 (90.7)	39 (86.7)
Track	39 (58.7)	—	—
Ground	17 (25.4)	21 (32.8)	32 (71.1)
Canopy	14 (20.9)	20 (31.3)	20 (44.4)

60% of the species were also found at the track. Only 21% of the fauna of Pine Creek was recorded above the canopy and of these only one species, an unidentified Lycaenid, was found solely above the canopy.

At Curtain Fig 91% of the butterfly species were found on the edge of the habitat with approximately one third of the species recorded on the ground and above the canopy. There were two species of butterfly which were only found above the canopy, these were a Lycaenid in the genus *Erysichton* and an unidentified Lycaenid.

At 40 Mile Scrub, where the canopy is lower and less dense, the majority of species were recorded on the edge of the habitat (87%) but substantial numbers of species (71%) were also found on the ground and in the canopy (44%). One species of Lycaenid was observed only above the canopy, a member of the genus *Nacaduba*.

In Table 3 the spatial distribution of the butterfly fauna of Pine Creek is

Table 3. The spatial distribution (cumulative coded abundance) of the most abundant butterfly species in each family at Pine Creek.

Family	Species	Edge	Track	Ground	Canopy	Total
Papilionidae	*Graphium agamemnon*	13	12	4	2	31
	Princeps ulysses	12	4	0	1	17
	P. ambrax	2	6	0	0	8
Pieridae	*Delias mysis*	8	9	5	4	26
	Catopsilia pomona	4	4	0	2	10
	Eurema hecabe	10	0	0	0	10
Nymphalidae	*Mycalesis terminus*	48	21	1	0	70
	M. perseus	15	0	0	0	15
	Tellervo zoilus	0	26	9	0	35
	Cupha prosope	2	12	3	0	17
Lycaenidae	*Danis danis*	0	15	6	3	24
	D. cyanea	17	2	0	0	19
	D. hymetus	5	8	0	0	13
Hesperiidae	*Suniana sunias*	30	9	0	0	39
	Pelopidas agna	20	0	0	0	20
	Tagiades japetus	5	10	0	0	15
	Notocrypta waigensis	1	12	0	0	13

examined in more detail. Some species are found only or mostly on the edge of the habitat (*Danis cyanea, Eurema hecabe, Mycalesis perseus, Princeps ulysses, Pelopidas agna, Suniana sunias*) some are found on the edge and the track (*Danis hymetus, Mycalesis terminus*), whereas others tend to occur more often on the track (*Cupha prosope, Notocrypta waigensis, Princeps ambrax, Tagiades japetus*). Two species (*Danis danis* and *Tellervo zoilus*) appear to be restricted to below the canopy and two species occur frequently in all four zones (*Delias mysis* and *Graphium agamemnon*).

Similar comparisons can be made at Curtain Fig (Table 4) at which *Elodina angulipennis, Lampides boeticus, Mycalesis terminus, Ocybadistes walkeri, Princeps ulysses, Pieris rapae* and *Suniana sunias* comprise the edge fauna. There are two species (*Princeps ambrax* and *Sabera fuliginosa*) which occur at the edge and under the canopy. Several species occur in all three locations, but there are two which are found most often in the canopy (*Delias nigrina* and *Graphium macleayanum*).

At 40 Mile Scrub (Table 5) *Syntarucus plinius* is the only species found solely at the edge and, although several species were most abundant at the edge, most were found in all three spatial locations.

Table 6 examines the spatial distribution of the rich hesperiid fauna at Pine Creek. It is clear that members of the same genus tend to occur in the same spatial location. Species in the genera *Arrhenes, Ocybadistes, Pelopidas, Suniana* and *Telicota* are found on the edge of the rain forest whereas species in the genera *Chaetocneme, Notocrypta, Sabera, Tagiades* and *Toxidia* tend to occur on the track or under the canopy.

DISCUSSION

The results of this study must be interpreted with caution because only three study sites could be used (there are only three sites with access to the rain forest

Table 4. The spatial distribution (cumulative coded abundance) of the most abundant butterfly species in each family at Curtain Fig.

Family	Species	Edge	Ground	Canopy	Total
Papilionidae	*Graphium macleayanum*	11	1	17	29
	G. sarpedon	8	1	5	14
	G. agamemnon	4	5	2	11
	Princeps aegeus	12	4	1	17
	P. ambrax	7	6	0	13
	P. ulysses	8	1	2	11
Pieridae	*Delias nigrina*	3	1	9	13
	D. mysis	6	1	3	10
	Pieris rapae	13	0	0	13
	Elodina angulipennis	7	1	1	9
Nymphalidae	*Mycalesis terminus*	10	0	0	10
Lycaenidae	*Candalides absimilis*	5	5	6	16
	Lampides boeticus	15	0	0	15
Hesperiidae	*Suniana sunias*	20	0	0	20
	Ocybadistes walkeri	12	0	0	12
	Sabera fuliginosa	7	5	0	12

Table 5. The spatial distribution (cumulative coded abundance) of the most abundant butterfly species in each family at 40 Mile Scrub.

Family	Species	Edge	Ground	Canopy	Total
Papilionidae	*Princeps aegeus*	14	9	6	29
	Graphium eurypylus	11	5	4	20
Pieridae	*Eurema hecabe*	26	23	6	55
	Appias paulina	15	16	13	44
	Catopsilia pyranthe	20	10	6	36
	C. scylla	12	6	7	25
	Elodina angulipennis	11	10	7	28
Nymphalidae	*Euploea core*	13	8	5	26
	Phaedyma shepherdi	11	5	0	16
	Tirumala hamatas	8	3	4	15
Lycaenidae	*Nacaduba berenice*	9	8	11	28
	Lampides boeticus	12	12	0	24
	Syntarucus plinius	10	0	0	10
Hesperiidae	*Badamia exclamationis*	5	1	5	11

Table 6. The spatial distribution (cumulative coded abundance) of the Hesperiid species at Pine Creek.

Species	Edge	Track	Ground	Canopy	Total
Chaetocneme porphyropis	0	0	1	0	1
Badamia exclamationis	1	2	0	0	3
Tagiades japetus	5	10	0	0	15
Toxidia rietmanni	0	1	1	0	2
T. melania	0	3	0	0	3
Notocrypta waigensis	1	12	0	0	13
Ocybadistes flavovittatus	1	0	0	0	1
O. walkeri	1	0	0	0	1
O. ardea	1	0	0	0	1
Suniana sunias	30	9	0	0	39
Telicota colon	6	0	0	0	6
T. augiades	10	1	0	0	11
T. mesoptis	8	1	0	0	9
Cephrenes augiades	1	0	0	0	1
Sabera caesina	0	6	1	0	7
S. fuliginosa	0	6	0	0	6
S. dobboe	0	8	0	0	8
Pelopidas agna	20	0	0	0	20
P. lyelli	5	0	0	0	5

canopy in northern Australia). In addition only one set of spatial locations was used at each site (since there was only one canopy tower at each site). Nevertheless the results of cumulative number of species over time show that sampling was sufficiently intensive to describe adequately the butterfly fauna at each site. Each site possessed a diverse fauna in which each family contained several species, the exception being the hesperiids at 40 Mile Scrub. Whilst there are surprisingly few published records available, a comparison with the available information

and personal observations suggest that the butterfly fauna of each site is typical for each rain forest type (Kahn & Lawrie 1987, Monteith & Hancock 1986). There are several species, particularly in the Lycaenidae, which are recorded from this region but did not appear in this study (e.g. Kitching 1981). This discrepancy is probably due to the use of only three locations for study sites, the reasons for which have already been outlined.

Although the canopy contains 21–44% of the butterfly fauna, there are very few species whose distribution is predominantly in the canopy. Species which were seen only in the canopy are individual Lycaenids which could not be identified to species using binoculars. At all of the sites the edge of the habitat contains by far the highest proportion of species, and some of these species are only found on the edge of the habitat. These species may be breeding in nearby habitats and using the edge primarily as a feeding habitat (Wiklund 1977) since *Lantana camara* L. and *Stachytarpheta jamaicensis* (L.) Vahl (two commonly used adult nectar plants) grow profusely on the edge of rain forests. Most of the species which occur within the rain forest are also found on the edge of the habitat. Numerous feeding observations suggest that they too are using the edge as a foraging habitat. There are however a few species, particularly at Pine Creek, which do not occur on the edge of the rain forest and were seen only along the track and in below-canopy habitats. These species might be classified as shade-tolerant specialists: they include *Danis danis*, *Tellervo zoilus* and the hesperiid genera *Chaetocneme*, *Toxidia*, *Notocrypta* and *Sabera*.

Papageorgius (1975) found that the butterfly fauna of forests in Peru was vertically stratified with members of the same Mullerian mimicry ring tending to fly at the same heights. Similarly, Jackson (1961) describes the occurrence of many new species from a canopy tower in the Mpanga Forest, Uganda. Interestingly most of these species belonged to the Lipteninae (a subfamily of the Lycaenidae) whose larvae feed on lichens on tree trunks. The Lipteninae are absent from Australia and as yet no such specialised arboreal life cycles have been described for Australian lycaenids. In contrast, the results of this study suggest that the Australian rain forest butterflies, at least in the adult stage of their life cycle, are not stratified in this way. In particular no evidence has been found for a specialist canopy fauna different from that observed from the ground. Interestingly Majer (1990) has shown that the ant fauna in the canopy of Australian rain forests is not diverse. The spatial distribution of the larvae of Australian rain forest butterflies remains to be described and may be important. For instance, the observed distribution of adult hesperiids at Pine Creek may well be explained in terms of the distribution of larval foodplants. Larvae of the genera commonly found on the edge of the habitat feed on grasses, whereas those found within the habitat mostly feed on certain species of tree, shrub or vine growing within the rain forest (Common & Waterhouse 1981).

In practical terms the results of this study suggest that the butterfly fauna of tropical Australian rain forests can be adequately surveyed without access to the canopy, but care should be taken to include both the edge of the habitat, and

any within-habitat spatial variation in the sample. It also suggests that the family mostly likely to be under-represented in a visual census is the Lycaenidae.

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Appendix 1. A list of the butterfly species recorded at each of the three study sites and their range of coded abundance (1: 1, 2: 2, 3: 3–5, 4: 6–9, 5: > 10) at that site. The species are listed in the same order as appears in Common & Waterhouse (1981).

Species	Pine Creek	Curtain Fig	40 Mile Scrub	Species	Pine Creek	Curtain Fig	40 Mile Scrub
Family Papilionidae				**Family Nymphalidae**			
Protographium leosthenes leosthenes (Doubleday)			1	*Danaus plexippus plexippus* (Linnaeus)		1	
Graphium macleayanum wilsoni Couchman		1–5		*D. chrysippus petilia* (Stoll)			1–3
G. sarpedon choredon (C. and R. Felder)	1–2	1–3		*Tirumala hamatas hamatas* (W.S. Macleay)	1		1–5
G. eurypylus lycaon (C. and R. Felder)	1	1	1–5	*Euploea core corinna* (W.S. Macleay)	1	1	1–5
G. agamemnon ligatum (Rothschild)	1–5	1–4	1	*E. sylvester sylvester* (Fabricius)			1–2
Princeps aegeus aegeus Donovan	1	1–4	1–5	*E. tulliolus tulliolus* (Fabricius)	1		
P. fuscus capaneus Westwood			1	*E. darchia darchia* (W.S. Macleay)	1		
P. Ambrax egipius Miskin	1–2	3–4		*Tellervo zoilus zoilus* (Fabricius)	1–5	1	
P. ulysses joesa Butler	1–4	1–4		*Melanitis leda bankia* (Fabricius)	1	1	
Cressida cressida cressida (Fabricius)		1	1	*Mycalesis terminus terminus* (Fabricius)	1–5	1–5	
Ornithoptera priamus euphorion (Gray)	1	1		*M. perseus perseus* (Fabricius)	1–5		
				Hypocysta irius (Fabricius)	1–3		
Family Pieridae				*H. metirius* Butler		1–3	
Catopsilia pyranthe crokera (W.S. Macleay)		1	1–5	*H. pseudirius* Butler			1–4
C. pomona pomona (Fabricius)	1–3	1	1–4	*Tisiphone helena* (Olliff)	1		
C. scylla etesia (Hewitson)			1–5	*Xois arctoa arctoa* (Fabricius)	1	1–3	
C. gorgophone gorgophone (Boisduval)	1			*Polyura sempronius sempronius* (Fabricius)			1–2
Eurema brigitta australis (Wallace)		1		*Phaedyma shepherdi shepherdi* (Moore)		1	1–3
E. hecabe phoebus (Butler)	1–3	1–2	1–5	*Neptis praslini staudingereana* de Nicéville	1		
E. smilax (Donovan)			1–3	*Pantoporia consimilis consimilis* (Boisduval)	1–2	1–2	
E. herla (W.S. Macleay)			1–3	*Mynes geoffroyi guerini* Wallace		1–4	
Elodina parthia (Hewitson)			1	*Doleschallia bisaltide australis* C. and R. Felder	1		
E. angulipennis (P.H. Lucas)		1–4	1–4	*Hypolimnas bolina nerina* (Fabricius)	1	1–3	1–3
Delias mysis mysis (Fabricius)	1–3	1–2		*H. alimena lamina* Fruhstorfer	1	2	1
D. ennia nigidius (Miskin)		2		*Vanessa itea* (Fabricius)		1–2	
D. nigrina (Fabricius)	1–2	1–3		*Junonia hedonia zelima* (Fabricius)	2	1	
Anapheis java teutonia (Fabricius)			1–3	*J. villida calybe* (Godart)		1	3
Cepora perimale scyllara (W.S. Macleay)	1		1–3	*J. orithya albicincta* Butler		1	1–2
Appias paulina ega (Boisduval)	1	1	1–5	*Cethosia cydippe chrysippe* (Fabricius)	1–4		
Pieris rapae rapae (Linnaeus)		1–5		*Vindula arsinoe ada* (M.R. Butler)	1		

continued

Appendix 1. *continued*

Species	Pine Creek	Curtain Fig	40 Mile Scrub
Family Nymphalidae *continued*			
Vagrans egista propinqua (Miskin)	1–3	1	
Cupha prosope prosope (Fabricius)	1–3	2	
Acraea andromacha andromacha (Fabricius)	1	1	1–2
Family Lycaenidae			
Philiris nitens nitens (Grose-Smith)	1		
Arhopala micale amphis Waterhouse	1–2		
Candalides margarita margarita (Semper)		1	
C. helenita helenita (Semper)		3	
C. absimilis (Felder)	1–3	3–5	
Candalides sp.		1–2	
Nacaduba berenice berenice (Herrich-Schäffer)			1–5
N. kurava parma Waterhouse and Lyell		1–2	1–3
Nacaduba sp.			1
Prosotas dubiosa dubiosa (Semper)	1	1–3	
P. nora auletes (Waterhouse and Lyell)	1–5	1	
Prosotas sp.	1–4		
Catopyrops florinda estrella (Waterhouse and Lyell)			1–3
Erysichton sp.		1	
Danis danis serapis Miskin	1–3		
D. hymetus taletum (Waterhouse and Lyell)	1–4	1	
D. cyanea arinia (Oberthür)	1–5		
Jamides aleuas coelestis (Miskin)	1–3		
J. phaseli (Mathew)			4
Catochrysops panormus platissa (Herrich-Schäffer)		1	1–4
Lampides boeticus (Linnaeus)	1	1–4	1–5
Syntarucus plinius pseudocassius (Murray)			3–4
Zizeeria karsandra (Moore)			2–4
Family Lycaenidae *continued*			
Zizina labradus labradus (Godart)			1
Zizula hylax attenuata (T.P. Lucas)		1	1–3
Megisba strongyle nigra (Miskin)		1	
Freyeria trochylus putli (Kollar)			1–4
Family Hesperiidae			
Badamia exclamationis (Fabricius), 1775	1–2	3–4	1–5
Chaetocneme porphyropis (Meyrick and Lower)	1		
Tagiades japetus janetta Butler	1–3		
Toxidia parvula (Plötz)			1
T. rietmanni parasema (Lower)	1		
T. melania (Waterhouse)	1–2		
Notocrypta waigensis proserpina (Butler)	1–4		
Ocybadistes flavovittatus ceres Waterhouse	1	1	
O. walkeri sonia Waterhouse	1	1–4	1
O. ardea heterobathra (Lower)	1	1–3	
Suniana sunius rectivitta (Mabille)	1–5	2–4	
Arrhenes dschilus iris (Waterhouse)	2–4	1–2	
Telicota colon argeus (Plötz)	1–5	1	
T. augias krefftii (W.J. Macleay)	1–4		
T. ohara ohara (Plötz)		1	
T. mesoptis mesoptis Lower	1–3	1–4	
Cephrenes augiades sperthias (Felder)	1		
Sabera caesina albifascia (Miskin)	1–2		
S. fuliginosa fuliginosa (Miskin)	1–3	3–5	
S. dobboe autoleon (Miskin)	1–3		
Pelopidas agna dingo Evans	1–5	1	
P. lyelli lyelli(Rothschild)	1–2	1–3	1