Aspects of the biology and behaviour of *Candalides consimilis goodingi* (Tindale) near Melbourne, Victoria (Lycaenidae: Polyommatinae)

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Abstract
Adult temporal behaviour of *Candalides consimilis goodingi* (Tindale) is examined using a time-sampling approach spanning one full day in spring, near Melbourne, Victoria. Aspects of adult vagility and male territoriality are discussed with speculation on adult visual recognition factors for mate location. Flight activity commenced mid-morning and continued through to late afternoon, with significant positive correlations found between adult numbers, feeding bouts and temperature. Male abundance peaked in early mid-afternoon, females were seen more often during late afternoon, but they remained scarce comprising less than 12% of sighted adults. Both sexes perched at moderate heights, often on trees with shiny leaves. Higher perch sites were selected later in the afternoon. Males occasionally explored habitat flying up to 56m from a localised focus, but females could not be found again once they had departed the foraging area. Adult behaviour involved courtship refusals, inspection of settled adults and bird dung, perching, feeding, basking and roosting as part of a typical day's activity. Interpretations of behaviour and data analyses were based on a maximum sample size of 85 individual butterfly observations.

Introduction

Changes in abundance of various species are routine phenomena and unremarkable normally. Their causes are various. Commonly these involve proliferation of larval hosts at a local level, the presence of particular landforms that serve to concentrate males, or influxes from migrations. Other examples such as aggregative behaviour for seasonal diapause or nocturnal roosting, and foraging of adults at sites of nectar or mineral concentrations to meet dietary or biochemical requirements will be familiar to most. In the case of nectaring, many observers of butterflies have probably chanced upon what is termed 'localised feeding phenomena', an exceptional occurrence of a species' abundance, distinct from the general species richness familiarly linked to nectar resources and environs. The prominent feature in 'localised feeding phenomena' is that the species concerned is usually rarely seen, becomes unusually abundant for a short period then vanishes for seasons or even decades. An example has been reported for the polyommatine lycaenid, *Psychonotus julie* in the Solomon Islands of which Tennent (2002: 92) wrote experientially. "Many tropical forest lycaenid butterflies are attracted, sometimes in large numbers, to a particular flowering tree or shrub for a period of several days, presumably when nectar production is high, and may not be encountered again." The incidence seems more notable in equatorial and wet-tropical regions where seasons are less marked and fewer species spatially dominate. Proliferation of hosts occurs rapidly following monsoons. These wet seasons can be irregular in timing and spatially patchy in northern Australia, and enhanced by cyclonic depressions. Resultant new foliage enables a matrix of metapopulations to quickly arise and decline, creating prominent fluctuations in adult abundance at the local level. In cool temperate latitudes, butterfly abundance occurs seasonally in response to changes in ambient temperature instead, but seems less mysterious mainly because many species show this temporal regularity. Several species may spatially co-dominate for a time, often over a vast area, creating an appearance of ubiquity. The Bassian satyrines in eastern Australia is one such group that quickly springs to mind.

I recently wrote of one unusual occasion that occurred in late November 2001 (Dunn 2006). A localised population of *Candalides consimilis goodingi* (Tindale) unexpectedly appeared in a hilltop garden opposite Hamilton Reserve, 4km ENE of Upper Beaconsfield, in an area where adults had not been seen previously despite regular observations over several years. Adult presence was limited to that spring season. Poor weather set in soon after its discovery and at the next available opportunity for observations, none was present (Dunn 2006). Adult foraging had focussed on a single *Callistemon* sp., almost certainly *viminalis*, then at its flowering zenith – evinced by the audible presence of numerous honeybees. Four other *Callistemon* bushes (several species) growing nearby (Figure 1) and in various stages of flowering, attracted none of these butterflies and bee attendance at each was limited (Dunn 2006). Disappointingly, the population vanished after 2001 – the following season (2002) being "one of Australia's driest years on record" (Braby & Douglas 2004: 288) and its severity may have extirpated it. Variations in southern oscillations have been linked to remarkable expansions or contractions of species' distributions (Dunn & Dunn 2006), and establishment or decline of transient metapopulations, as in this instance, are a part of this phenomenon. Causation aside, the propitious presence of *C. consimilis* in a home garden enabled a full-days' observation on foraging, territorial and courtship behaviour with ease of access to facilities. The results of these systematic observations on 22 Nov 2001 are examined, this paper being adjunctive to my earlier behavioural observations on this butterfly (Dunn 2002, 2006).

Taxonomy and identification

Within the Candalidini, Tite (1963) earlier partitioned *C. consimilis* in the '*Holochila* group,' mistakenly believing the type species of C. Felder's grouping to be the taxon *absimilis*. Soon after, Tindale (1965) popularised this anomalous arrangement among the amateur fraternity when he named *Holochila goodingi* as a new species. *Holochila* is in fact a junior objective synonym of *Erina* (Edwards *et al*. 2001), and I like others schooled in Tindale's writings have had to unlearn this. Where required for ease of communication, selection of the title '*absimilis* group' is a useful compartmentalisation within this broad and variable genus. Moreover, one or more South Australian experts have favoured the formal generic subdivision of *Candalides* (eg. Grund 2005). Nonetheless, I remain content with the status quo as retained in Braby (2000) despite growing recognition of apparent behavioural differences across the genus (Dunn 2002). As part of identification rigour for this autoecological study, two male vouchers were preserved. One has been lodged is the ANIC, Canberra, the other remains privately held (KLDC).

Interpreting stances and behaviour

Males of many species of butterfly perch with wings in the familiar dihedral angle, often referred to as the 'V-shape' stance, which varies in acuteness in response to environmental cues – posture standard among lycaenids. Butterflies rarely use the opposing anhedral stance, but moths commonly adopt it. A spectacular exception is the large Nymphalid *Parthenos sylvia* in New Guinea and SE Asia, a species I have observed favours lowering its forewing tips below the root of attachment when feeding or perched. Others such as *Vanessa* species (Nymphalidae) routinely adopt the horizontal stance. *C. consimilis* characterises many lycaenidae, selectively perching in various postures ranging from stances with wings held together vertically above the thorax (Dunn 2002, 2006), and categorised as the "wings-closed position" (Endersby 1995: 88), to occasional widely opened, almost horizontal displays (Dunn 2006).

Posturing may be multi-functional, often signalling adult presence to conspecifics, aposematic displays to would-be predators, and/or facilitating thermoregulation when required. In terms of optimising body temperatures, those with closed wings may be lateral basking, an adaptation commonly seen in small butterflies such as lycaenids (Douglas 1978 cited in Masters 1993). Among temperate Australian satyrines such as *Geitoneura*, I have observed that lateral baskers frequently tilt their wings to vary the degree of sun exposure to their thorax, maximising absorption during cool periods. They also tilt to reduce their shadow during mid afternoons when daily temperatures maximise during summer or for camouflage when approached. In contrast, dorsal basking involves wings opened to varying angles to regulate sunshine on the thorax. Stances where the butterfly faces upward and outward away from the sun, or downwards below the sun, optimise heat absorption. In a lycaenid study in Victoria, Endersby (1995: 90) determined that "almost invariably a basking butterfly will sit with wings spread and normal to the sun's direction." Yet, due to slow movement of haemolymph in veins, butterfly wings themselves cannot act as solar collectors (Masters 1993), contrary to popular assertions in the 1960s. Males facing anteriorly upward into the sun, rather than away, are likely to be compromising thoracic thermoregulation with territory surveillance. Some perched females may also be coyly signalling a measure of receptivity (or unreceptivity) to males.

Clearly then, interpreting behaviour in this polyommatine lycaenid is a subjective skill, open to some conjecture. The direction adults faced was not fastidiously recorded in my note-taking, creating later ambiguity as to whether particular adults were perched to ease rapid departure for inspection flights, signalling, or dorsal body-basking. Nonetheless, more adults were likely to body-bask during late afternoon, with declining shade temperatures. On this basis, I have interpreted the wider 'V-stances' exhibited by *C. consimilis* at that time to be basking postures in my outlines of their activities during watches.

Site

Locality: Opposite Hamilton Reserve, near Dewhurst region of Upper Beaconsfield, Victoria.
Altitude: 220m above sea level.
Habitat: Rural hilltop-residential garden surrounded by pasture, about 200m from stand of open eucalypt forest with understorey of *Leptospermum* and various sedges.

Data collection methods

Using a naturalistic and descriptive methodology, namely describing behavioural events as they occurred, I investigated the daily activity of this lycaenid. Two earlier communications covered event-sampled behaviours of courtship (Dunn 2002) and foraging (Dunn 2006), studied by means of unstructured observational data gathering. In this paper, territoriality and components of spatiality are instead the focus. I examined adult butterfly abundance using a time-sampling approach. Twenty-two (22) watches, each of ten (10) minutes, were conducted along a garden transect (75m) at regular time intervals spanning a full day. All adults seen flying or perched within 5m on either side of the transect-line were tallied for each watch period, similar to British transect monitoring (Asher *et al*. 2001). The population appeared extremely concentrated and localised, the adults being confined to an area of only 50 x 50m^2.

During and between watches, descriptive data were gathered using observer single-positioning for extended periods, but with short periods of observer multiple-positioning (changing positions often enabled clearer views of specific activities). Mobile positioning (following individual butterflies) was rarely required because males, within minutes, regularly returned to their perch sites after forays into surrounding habitat. Once airborne, females were difficult to track visually, remaining unaccounted for over lengthy time periods having either departed the study area or stealthily settled, undetected amidst foliage. The study method did not involve seeking out individuals.

In preparation for this study, I noted perch sites favoured the previous day (21 Nov 2001) and then optimally selected a transect line to enable adequate counts for data analysis. Adult presence was curvilinear in spatiality, modified by garden tree topography and adjoining building structures creating areas of unsuitable habitat. The transect decided upon included all perch sites selected by males, including the most distant perch site detected – a Camelia bush situated on the summit, some 56m from the bottlebrush where adults fed. No perch sites had been detected between the Camelia and the Lilly-pilly – an area of mown lawn with a row of tree-ferns (*Cyathea*), nor were there any situated to the west or northwest of the bottlebrush (*Callistemon*).

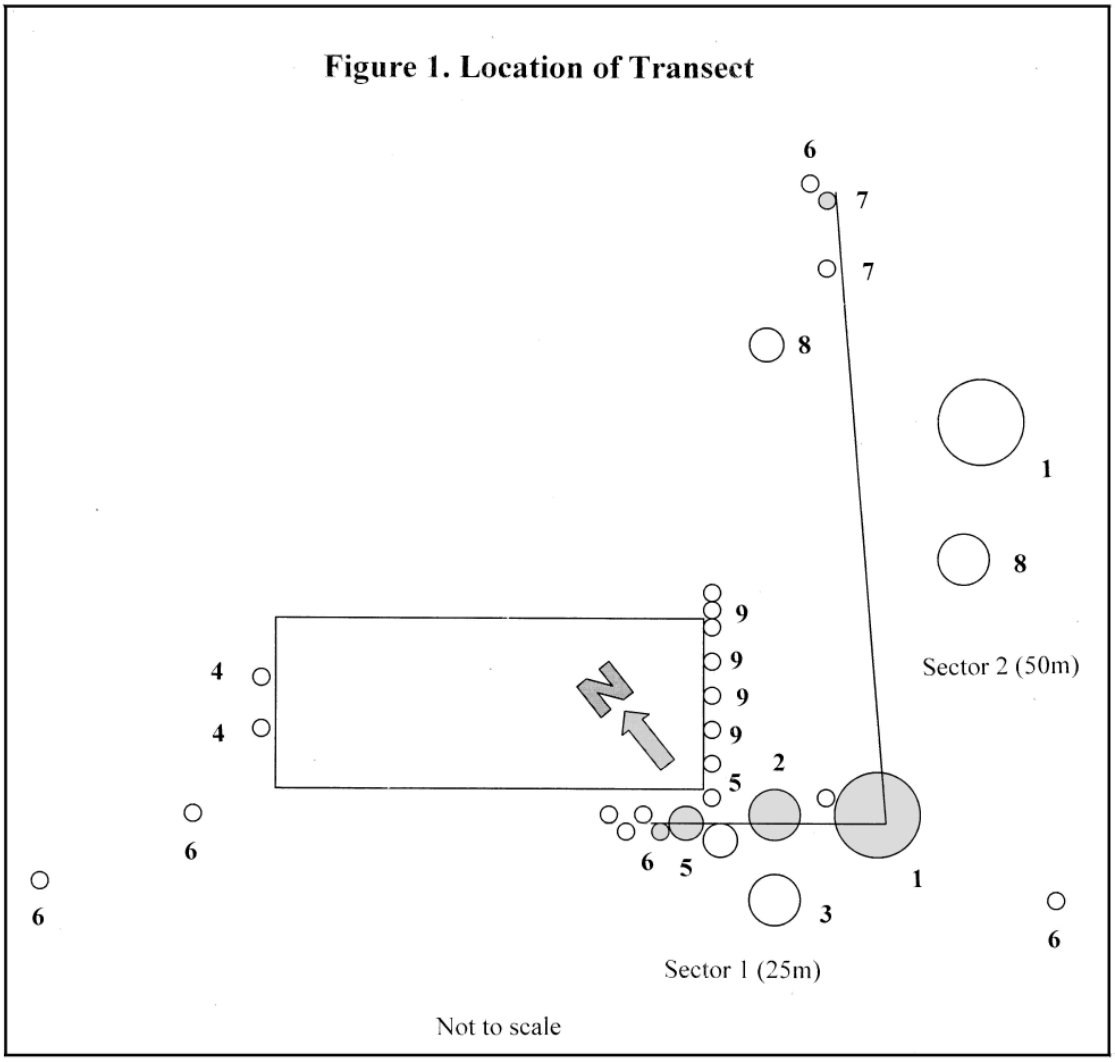

Figure 1. Schematic diagram of study area showing the two transect sectors and butterfly activity sites. Key: Lilly-pilly (**1**), Irish Strawberry tree (**2**), Eucalypt (**3**), Lantana (**4**), *Rhododendron* (**5**), *Callistemon* spp. (**6**), *Camelia* (**7**), Silver birch (**8**), Tree-ferns (**9**). Shaded circles indicate trees selected as perch sites; the foraging site is the shaded circle marked '6'. Larger circles indicate plants of larger volume. Several unnumbered circles represent unidentified adjacent trees or shrubs, or plants of lesser importance but included due to their close proximity to butterfly activity areas. The rectangle represents a house.

A 75m angled transect selected for adult observations during watch units (Fig. 1) thus comprised two connected sectors, one of 25m running southeast from the foraging site (Sector 1 – **S1**) abutting another of 50m continuing north-northeast (Sector 2 – **S2**). The transect angle of 65° centred on a massive Lilly-pilly tree (*Eugenia smithii*) (trunk about 1m diameter 30cm above ground) reaching a height of about nine metres. The smaller sector (25m) included an *Arbutusunedo* tree and *Rhododendron* shrub, and terminated just beyond the *Callistemon* (foraging site). A photograph looking southeast directly along S1 appeared in Dunn (2006: 32). The 50m sector extended north-northeast from the Lilly-pilly to the *Camelia* (Sector 2).

Watch periods

Daylight saving (DST) was in operation in Victoria during the study, however, times provided for all observations and periods have been returned to Australian Eastern Standard Time (AEST) to align with a solar noon. Thus, on that day, sunrise reported as at 0555h (Daylight saving time) occurred at 0455h AEST, solar noon reported at 1306h (DST) was at 1206h (AEST), and sunset at 2017h (DST) is similarly again adjusted back to 1917h (AEST). The 22nd Nov 2001 involved a day length of 14 hours, 21 minutes and 54 seconds.

Near Melbourne, during summer, butterflies are active throughout the day. I have observed numbers of *Zizina labradus* (Polyommatinae) rapidly patrolling clover in low light, as early as 0548h AEST (only 33 minutes after sunrise) following a warm January night. Towards the close of day, I have seen *Vanessa kershawi* (Nymphalinae) nectaring to at least 1825h AEST (75 minutes before sunset in December). Later than this, reduced light intensity makes ongoing detection of adult activity difficult. These are maximum times linked to optimal climatic conditions during the hotter months, but in spring and autumn, the period of daily flight-activity shortens. For *C. consimilis*, a species belonging to the largely tropical *absimilis* group, the hours 0700-1830h were selected and divided into 22 watch periods, each of 10 minutes. This survey allotment of 11.5 hours spanned the anticipated time of adult activity during the cooler conditions in spring, particularly for a species at its southern limits. Two watch periods were allocated to each hour except the final hour. Each commenced at 10 minutes and 40 minutes past the hour, repeating hourly from early morning to early evening (see Table 1) spanning the hours when temperature butterflies are active. The first watch (1) began at 0740h (AEST), at which time the tree tops where adults patrolled were then newly sunlit, this being 2 hours and 45 minutes after sunrise. The final watch (22) concluded at 1820h (AEST) when long shadows were evident and butterfly activity had ceased, being 57 minutes before sunset.

Situational variables

Endersby (1995) reported that sunlight together with adequate shade temperature seems a prerequisite for adult butterfly activity in the temperate thecline, *Paralucia pyrodiscus* near Melbourne, a locality towards the southern end of its geographic range. He noted that when air temperatures were low, flight was delayed until later in the day. Similar behaviour is likely among other lycaenids resident in cool temperate climates. One or more components may apply to *C. consimilis*, a species of similar distribution to *P. pyrodiscus*, and one likewise studied at a locality at the southern end of its range. For each watch, shade temperature was recorded and dominant weather conditions visually estimated and categorised (Table 1), given their likely collective effect on adult counts and activity. In general, fine weather and adequate temperatures persisted throughout the day, experientially judged continuously suitable for adult lycaenid activity. For the purpose of graphical comparison weather categories (sunshine and breeze components) were numerically scored between 0-14 (Table 1) for plotting against other variables (Figure 3).

Transect butterfly counts

At the start of each watch, transect S2 was walked first and visually checked for any perching adults (usually none was present). S1, where 98.8% of adults gathered, was then walked and adults counted. A raised (1.8m) verandah adjacent part of S1 served as a fixed-point observation post and conveniently permitted eye-level observations at about 3.6m height – equivalent to the lower strata of regular perch sites. The whole of S1 was then monitored continuously for the remainder of the watch from a fixed post. Spatially, the male aggregation skewed towards the flowering *Callistemon viminalis* at the end of S1 (Fig. 1).

In wings-closed position, perched adults were conspicuous to the unaided eye due to the reflective silverly underwing surfaces. Adult counts involved only those seen without deliberate disturbance of foliage. Counts were easy because males regularly patrolled habitat, then being highly visible, or periodically foraged where they remained for lengthy periods. They also showed site tenacity and selected conspicuous perch sites. Within any one watch, individual numbers were usually low. In total, no more than 14 adults were seen during a single watch (along the 25m transect) with an average of four adults seen per watch. During territorial altercations or when perching in moderate numbers, counting individuals was briefly challenging, but care was taken to avoid counting the same individual butterfly twice.

Results

Key to Table 1:

Adult abundance: 10-minute adult counts

High adult numbers (10-15 perched/flying adults present)	**H**
Moderate adult numbers (6-10 perched/flying adults present)	**M**
Low adult numbers (1-5 perched/flying adults present)	**L**
No adults detected (0 adults seen)	**Nil**

Table 1. period data

Day periods (AM)	Watch	Time (h) (AEST)	Shade temp. (°C)	Weather: measure of sunshine (with score)	Weather: wind factor	Adults
Early morning	1	**0740-0750**	12.0	Sunny (14)	Still conditions	**Nil**
Mid morning	2	**0810-0820**	13.2	Sunny (14)	Still conditions	**Nil**
	3	**0840-0850**	14.2	Sunny (14)	Still conditions	**7♂♂ M**
	4	**0910-0920**	15.5	Sunny with periods of translucent/hazy cloud cover (10)	Still conditions	**2♂♂ L**
	5	**0940-0950**	16.8	Sunny with periods of translucent/hazy cloud cover (10)	Still conditions	**3♂♂ L**
Late morning	6	**1010-1020**	16.8	Sunny (12)	Still conditions with occasional light breeze	**3♂♂, 1♀ L**
	7	**1040-1050**	22.0	Sunny (14)	Still conditions	**Nil**
	8	**1110-1120**	24.0	Sunny (14)	Still conditions	**5♂♂ L**
	9	**1140-1150**	25.4	Mainly sunny with one minute of overcast conditions (6)	Still conditions	**2♂♂ L**
Early afternoon	10	**1210-1220**	24.7	Translucent cloud cover with sunny periods (10)	Still conditions	**3♂♂ L**
	11	**1240-1250**	25.8	Sunny (12)	Light breeze	**8♂♂, 1♀ M**
	12	**1310-1320**	27.2	Sunny (14)	Still conditions	**2♂♂, 1♀ L**
	13	**1340-1350**	27.6	Sunny (12)	Light breeze	**6♂♂ M**
Mid afternoon	14	**1410-1420**	24.9	Sunny with periods of translucent/hazy cloud cover (10)	Still conditions	**14♂♂ H**
	15	**1440-1450**	24.3	Mainly overcast, but with brief sunny moments (2)	Still conditions	**Nil**
	16	**1510-1520**	25.0	Sunny (14)	Still conditions	**4♂♂ L**
	17	**1540-1550**	25.2	Sunny (14)	Still conditions	**8♂♂, 2♀♀ M**
Late afternoon	18	**1610-1620**	26.4	Sunny (14)	Still conditions	**3♀♀ L**
	19	**1640-1650**	24.9	Sunny (sun now shining roughly from WSW) (12)	Light breeze	**6♂♂, 1♀ M**
	20	**1710-1720**	23.9	Translucent cloud cover with sunny periods (8)	Light breeze	**1♀ L**
	21	**1740-1750**	23.3	Sunny with periods of translucent/hazy cloud cover; lengthening shadows (10)	Still conditions	**2♂♂ L**
Early evening	22	**1810-1820**	22.5	Overcast but with periods of translucent cloud cover; long shadows (1)	Still conditions	**Nil**

Table 2. Field Observations

Day periods (PM)	Watch	Time (h) (AEST)	General observations
Early morning	1	**0740-0750**	Two hours and 45 minutes after sunrise, much of 75m transect now sunlit, but adult foraging site (bottlebrush) still fully shaded by taller trees, only the tops of which are now sunlit. Many bees already foraging in the shade.
Mid morning	2	**0810-0820**	Tall trees and top of the bottlebrush now fully sunlit.
	3	**0840-0850**	Bottlebrush sunlit. Seven (7) adults: 3 perching in ‘V-shape’, 3 briefly patrolling with 2 entering territorial ‘dogfight’ disputes, across and about the treetops, ranging from 4-9m up. All activity on ENE side of trees. None feeding. One isolated male seen perching at 1m height on Camelia bush, facing out ENE towards the sun.
	4	**0910-0920**	Adults patrolling treetops, none seen perching.
	5	**0940-0950**	1 male feeding, 1 perching and 1 patrolling tops of shrubs.
Late morning	6	**1010-1020**	Female perching on foraging tree, facing west, with wings held in 70-90 degree ‘V’-shape. Males perching, facing ENE, occasionally patrolling, 2 males feeding.
	7	**1040-1050**	Suitable conditions continue for adult activity.
	8	**1110-1120**	One male feeding and 4 patrolling. A male of *Toxidia doubledayi* (Hesperiidae) seen perching near ground level and facing NE on leaves of a tree, along Sector 1; not interacting with *C. consimilis* being at a lower stratum.
	9	**1140-1150**	Adult activity confined to overcast (rather than sunny) weather, the overcast period lasting one minute. At this time 2 males suddenly appeared in the airspace, one honing in to feed. After feeding it briefly perched on foraging tree, then departed. A solitary male of *Heteronympha merope* (Satyrinae) seen flying across Sector 1 (also during the minute of overcast weather), its flight trajectory took it out of the study area. No *C. consimilis* intercepted it.

Table 2 continued. Field Observations

Day periods	Watch	Time (h) (AEST)	General observations
Early afternoon	10	**1210-1220**	Three males feeding.
	11	**1240-1250**	Males perching and patrolling one at treetop, with female on leaf seen refusing male courtship (documented in Dunn 2002: 4).
	12	**1310-1320**	One female seen flying along Sector 1 near Lilly-pilly. 2 males patrolling, one perching, now facing NW towards sun. NW sides of trees on Sector 1 now exposed to direct sunshine.
	13	**1340-1350**	2 males feeding, 1 perching on *Rhododendron* (facing NW with wings in narrow V, then wider V-shape: possibly basking), others patrolling and 2 'dog-fighting' in treetops.
Mid afternoon	14	**1410-1420**	5 males feeding, 2 on same flower spike, 3 perching with wings in V-shape (most facing NW, one facing WNW), others patrolling and 2 'dog-fighting' in treetops. One perched atop of Lilly-pilly (c.9m).
	15	**1440-1450**	Conditions for activity marginal.
	16	**1510-1520**	3 males feeding and 1 perching.
	17	**1540-1550**	Males periodically perching, with 6 feeding, 1 regularly patrolling. Two separate 'dogfights' with up to three individuals altercating at once. 2 females feeding and 'basking'.
Late afternoon	18	**1610-1620**	Females feeding at flowers and at sap, one 'basking' (wings held in wide 'V'-stance, angled at about 130 degrees).
	19	**1640-1650**	3 males perching, facing WSW with wings held in 'basking' (wide V-shape) position, one feeding and 2 patrolling; solitary 1 female resting amongst dense foliage.
	20	**1710-1720**	Solitary female 'basking' and flying.
	21	**1740-1750**	All sighted males now flying about top of Lilly-pilly and neighbouring tree, at 8-9m above ground, mostly about darked areas, perhaps seeking roosting sites for the night.
Early evening	22	**1810-1820**	Long shadows present with no signs of any flying or perching butterflies. Final watched ended at 57 minutes before sunset.

Discussion:

Flight period

A tally of 85 observations of *C. consimilis* was compiled over the 22 watches, 75 of these being of males, providing a male: female observation ratio of 15:2. Over many years of field collecting, I have found that, in general, male lycaenids are taken more often than females, and so this finding is not unexpected. Rearing of juveniles though has shown that many lycaenids have more-or-less equal emergence ratios. Evidently, in some site tenacious species, females may change in behaviour and become sedentary after mating (Dunn 2001). Hence, the low encounter rate reported here, may be attributable to coyness, (mated) females being reclusive, flying less often, and so rarely secured for collections (Dunn 1990). Concerning *Hypochrysops* near Cooktown, Queensland, for one example, I once reported how two females of *H. polycletus*, remained settled for lengthy periods, and selected the same leaves for days at a time (Dunn 1994). Others have reported similar observations, one example being Lane & Edwards (2004). Natural selection for reclusive strategies among females would optimise survival, enabling them extended opportunity to select and deposit eggs on the choicest hosts before falling prey to potential predators or other causes of mortality.

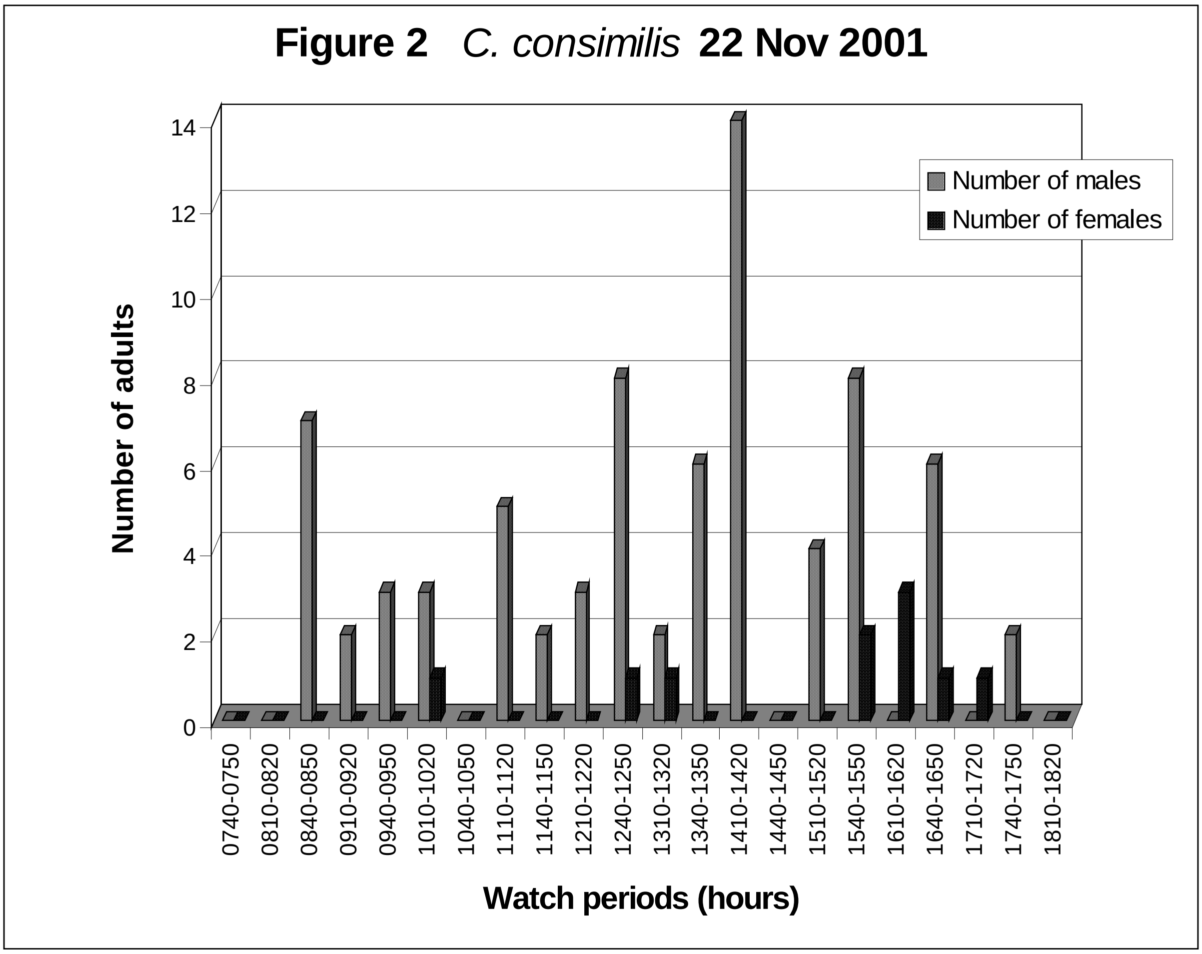

Figure 2. Numbers of each sex recorded per 10-minute watch period.

In a colony of Eltham coppers, sunlight and an adequate temperature were suggested as the perquisite for adults to become active (Endersby 1995), factors applicable to other temperate lycaenids. Males of *C. consimilis* were active at a minimum of 14.2°C from 0840h continuing more or less regularly through to 1750h, with highest abundance noted in midafternoon, during the 14th watch (Figure 2). Temperatures remained optimal (<30°C) throughout the day. Similarly, Endersby (1995: 85) found that Eltham coppers were active from about 1030h to 1600h "on a typical day". Females of *C. consimilis* were encountered spasmodically between 1010 and 1720 hours, and given the male predominance (88% of adults) their regular harassment would be expected.

Harassment is part of butterfly behaviour and can become physical in some species. In New Britain (PNG) I chanced upon an ovipositing female birdwing (Papilionidae) being courted by three persistent males with one male later striking her with his forewings and body, momentarily forcing her towards the ground (Dunn 2006a). Clearly, such attention is at odds with the female's inspection and egg-laying interests. On another occasion, I reported multiple males of a lycaenid harassing a female pierid that chance-resembled the colouring of their own much smaller female, forcing her to settle (Dunn 1996). For this reason, many gravid females of *C. consimilis* might be driven away to forage elsewhere. When the main male aggregations are focussed about sites of oviposition, particularly within richer breeding areas, females are prone to depart and lay on more isolated or boundary hosts, perhaps contributory to the 'edge effect' (Jones 1977). In this way, they avoid intense male attention (Dunn 2001) but a measure is still required to maintain presence. Zalucki (1993) has shown that danaine females will depart breeding areas if male numbers become too low. Not surprisingly, in *C. consimilis*, three females appeared during late afternoon in the 18th watch, when male competition for airspace was in decline. In parallel, an increase in female observation rate occurred during late afternoon (from 1600-1830h) in the Bull-oak Jewel butterfly, *Hypochrysops piceata* in southern Queensland (Dunn & Kitching 1994) – a member of the Theclinae.

Table 3. Nonparametric Correlation: Adults and sexes against environment

Spearmans rho

	Watch	Adults	Females	Males	Feeding
Temp	.549**	.473*	.435*	.352	.460*
Weather scores	-.342	.257	.292	.159	.109

Correlation significance: *****p<0.05 (two-tailed), ******p<0.01 (two-tailed)

Correlation test results

A nonparametric correlation was selected to analyse the scalar and ordinal parameters because the data were not normally distributed (Figure 3). **Significant results:** Temperature correlated positively with watch number as expected for a sunny day. Feeding activity (n=28 obs.) and adult presence (n=85 obs.) correlated positively with temperature, indicating only a 5% likelihood that the relationships are due to chance. The indicated female correlation is inadmissible given the low count for that sex (n=10). There was no significant correlation between weather and the number of adults observed (Table 3), although a minor trend can be seen, in that, when weather deteriorated (watches 4, 9, 15, 20) adult numbers declined (Fig. 3). Among lycaenidae, similar behaviour has been reported anecdotally for genera of both thecline and polyommatine groups (Muller & Sands 1999 and Hara & Hirowatari 1989, being two examples from the broader Australia-Pacific region). Finally, more adults were noted feeding in the afternoon (Figure 4), although no significant correlation was detected with watch period.

Adult Spatiality

Most males perched near the top of the Irish Strawberry tree (*Arbutusunedo*), between 3.5-4.5 metres above ground, and from their vantage points, overlooked the foraging site (Sector 1). Perch sites on neighbouring trees were more varied, ranging from one to nine metres above ground. Most males selected territories within 10m of the foraging site (*Callistemon*), but two had established perch sites farther afield. One perched 20m away and another, more isolated individual, perched on a *Camelia* 56m away. This latter male, situated on a rise on the summit, was within 10m of a second *Callistemon*. Selection of this perch site obviously linked to the local topography given the species is a frequenter of hilltops (Hunting 1980a,b, 1984, Dunn 2006), but some measure of influence by the second foraging site seems evident. The *Callistemon* at the summit may have been secondarily used for foraging by one or more adults, but unobserved during transect counts and the unstructured observations the previous day. Perching at this site (Sector 2) occurred during mid morning (Watch 3 only) when the other nectar source remained partially shaded. The male was not present there in the afternoon, having perhaps relocated to Sector 1 – the possibility of mortality being less likely. Its later absence reinforces the nectar source as the attraction rather than the landform; and in my experience hill topping in butterflies normally intensifies in the afternoon. Over the years I have observed males of various hill-topping species, such as *Tisiphone abeona*, *Heteronympha merope*, *H. paradelpha* (Satyrinae), *Dispar compacta* (Hesperiidae) and *Delias harpalyce* (Pieridae), patrol in this limited area. Each during their respective flight seasons, irrespective of whether bottlebrush blossoms were present.

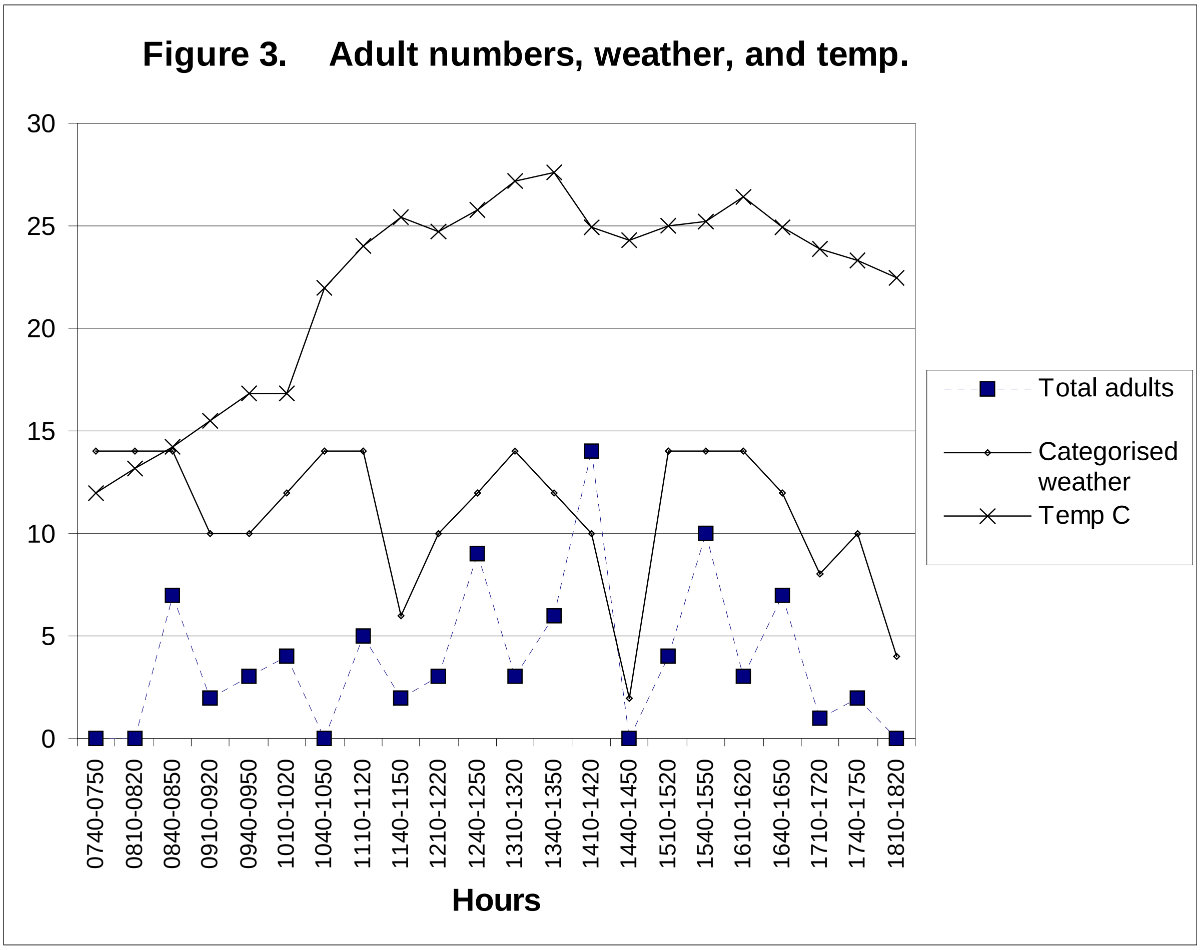

Figure 3. Total adults against categorised weather and temperature (22 Nov 2001)

Vagility

Males perched only briefly, up to about one minute (several timed), before being repeatedly enticed to pursue one or more patrolling males, with as many as three individuals interacting in territorial disputes simultaneously. Short perching times likely reflect the frequent presence of other males in the immediate airspace.

During exploratory patrols, males were seen crossing areas of lawn up to 50m away from the focus nectar source. Most patrols extended up to 20m from the point of origin (perch site) and remained confined to stratum equating to the uppermost foliage of nearby trees. Adult presence was highly localised about the foraging area (Dunn 2006); none was seen elsewhere in the adjacent open woodland, despite an extensive search the previous day. Remarkably similar behaviour has been noted in the Eltham Copper butterfly; Endersby (1995) reported highly confined adult activity, focussed instead about the larval hosts. Adults of *P. pyrodiscus* were noted up to 40m away from the colony aggregation, but this was a rare event.

Evidently neither species wanders far from its favoured habitat, and yet the population of *C. consimilis* must have gathered from a source population farther afield. Larvae of *C. consimilis* feed mainly on *Polysacias* in central Victoria (WNB Quick cited in Braby 2000) but none was located in the adjacent Hamilton Reserve (Dunn 2006). I suspect one or more larval hosts must have been present somewhere within several hundred metres, and probably to the WSW below the gentle summit rise – the direction in which females departed periodically. The presence of butterfly species closely links to growing larval hosts and availability of nectar. Both are essential survival resources (Dingle *et al*. 2000), the former being the more important determiner of species presence in terms of locale richness (Hill 1986).

Perch site selections

The Irish Strawberry tree has reflective, shiny leaves and dense foliage. When perched thereon the butterflies' silvery underwing surfaces aided camouflage, sparkling like those of the leaves in the gentle breeze. Others perched on the non-glossy foliage of the *Rhododendron*, situated closer to the focus nectar source, where they were more conspicuous (Dunn 2002). None perched atop of the taller eucalypt nearby. However the Lilly-pilly, a tall rainforest tree, attracted a couple of males, and like *Arbutusunedo* it too had very dense foliage with somewhat shiny leaves. Similarly, at Cape Byron NSW, I encountered males of *C. consimilis* perched on the shiny-leafed rainforest trees of medium height on gentle hilltops. Perhaps males prefer trees that offer some camouflage for their reflective undersides, at the expense of perch sites on less lustrous but higher foliage on other trees.

Foliage preferences aside, the selected perch sites and corresponding flight space rose in stratum as the sun declined. During the latest watch in which adults remained active (Watch 21), those seen had moved atop of the Lilly-pilly, about 9 metres above ground, thrice higher perches compared with those at 3.5-4.5 metres, favoured during much of the day. Irrespective of the change, *C. consimilis* is clearly a tree-dweller. For *P. pyrodiscus*, Endersby (1995) noted similarly, that later in the day adults moved to perch on taller plants. Although these two species occupy very different strata (the Eltham Copper being largely a ground dwelling species), the behaviour of rising perches with declining sunshine parallels in each. Roosting obviously occurred in the evening but no adults were detectable (final watch) due to the height of the trees and lowered visibility as twilight commenced.

Adult recognition cues

Males of some species of butterfly which perch with wings in the familiar dihedral angle (the 'V-shape') may signal to other males which detect ultraviolet reflection (Silberglied 1984: 222). During lateral basking the silver underwing colouration in *C. consimilis* no doubt reflects a full spectrum of sunlight, which would likely include ultraviolet. The wings-closed stance clearly signalled adult presence to other males, which would on occasion hone in to the underwing surfaces. When inspected, closed-winged males would remain quiescent, rather like unreceptive females, and after one or two inspections, patrolling males seemingly ignore these same settled adults. In contrast, males in dihedral angled wing stances often rose to aggressive pursuits of passing conspecifics, resulting in accelerated interactive flights ('dog-fights') rising some nine metres or more before separating to perch again. Males similarly investigated any settled females with closed wings, which similarly strongly reflected sunlight. Males in some butterfly groups may also respond to repulsion pheromones emitted by unreceptive females. It was noted in an earlier report that those females seemingly rejected by patrolling males "had been settled for sometime" (Dunn 2002: 5), an elapsed time enabling chemical odours to become detectable during still conditions. Endersby (1995) suggested Eltham coppers similarly respond to visual or olfactory cues.

Inspection of bird dung

It may be protective, aiding camouflage from predators, if 'basking' females or closed-winged adults superficially mimicked bird dung. White bird dung splashed on dark leaves strongly reflects white light in bright sunlight, and so might reflect a similar spectrum to the underwing surfaces of a closed-winged adult (components of which cue male investigation). Inspection of dung suggests visual attraction as part of mate location. Three males honed in to and flew several centimetres above sunlit bird dung deposited on a *Rhododendron* leaf at 3m height. One male landed alongside it (not over it) for a second or so before departing – similar behaviour occurs when a male inspects a female (see Dunn 2002 for description of courtship). Although utilised as a mineral resource in some polyommatine genera (eg. *Chilades* in Mindanao – Dunn 2001a), no adults fed at dung. This safely eliminates intent to forage as a possible reason for their attraction.

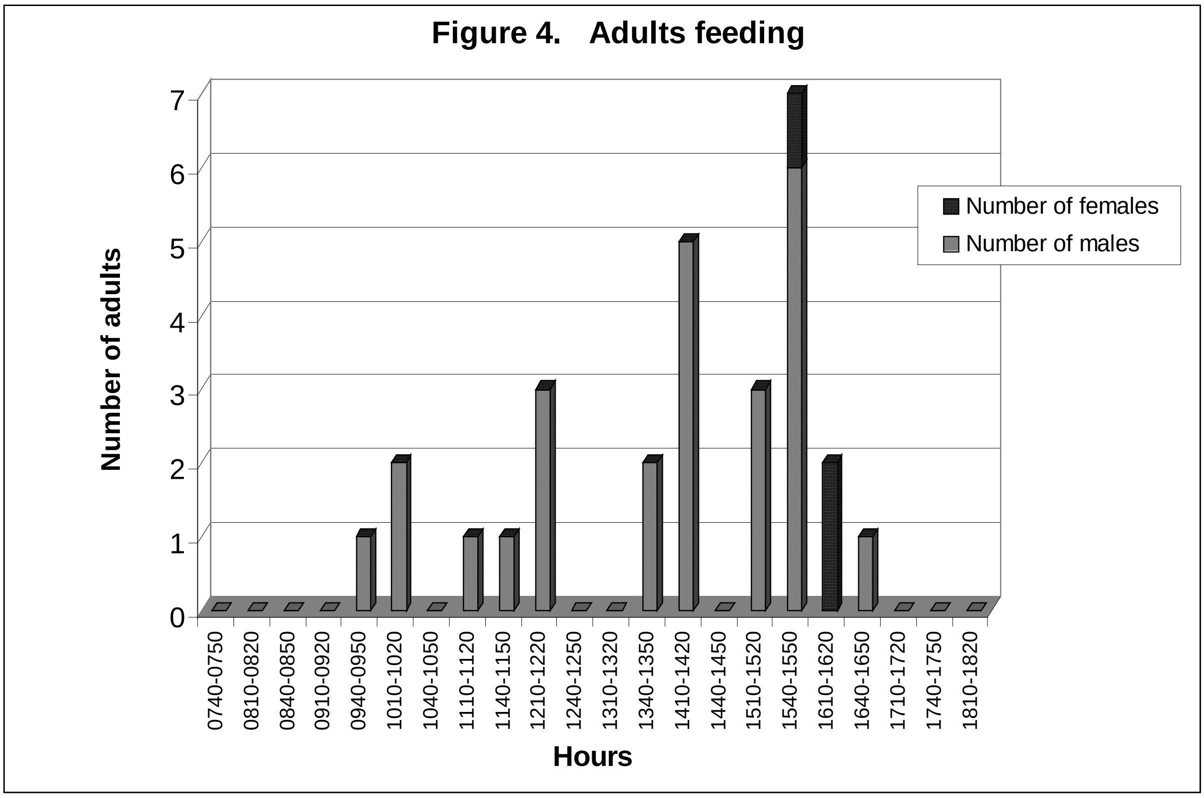

Figure 4. Number of adults recorded feeding during watch periods (n=28 observations)

In the female, the forewing central white spot contrasting a darker background colour, is remarkably like black and white bird dropping, and might be part of the mimicry, presumably cuing male investigations. Yet, a passing male was observed not to inspect a prominently perched female in V-stance. Of this single observation, I wrote earlier: “She settled … with wings in V-shape, and forewing anal margins drawn in parallel body… basking for several minutes, revealing [her] white forewing spot, but showing none of her hindwing. Another male passed by, several metres away, but did not approach” (Dunn 2002: 4). Perhaps this passing male simply overlooked her, but others flying at a similar range, quickly honed in to either sex perched with closed wings. More observations of male inspection of open-winged females in this subgroup of *Candalides* are required to gain a fuller picture of their attractiveness as part of mate location.

Limitations

Small samples weaken the detected correlations with ambient temperatures, particularly the feeding component examined (n=28). Replicate studies at other localities in different seasons would help strengthen significant correlations revealed in this study. They may also help elucidate any causatives of behavioural patterns, or clarify as chance or otherwise, one or more data trends noted in this study.

Conclusions

Using transects and time-sampling this study has demonstrated that males of this species are more often sighted than females at points of aggregations. Under ideal spring conditions, typical of that study day, both sexes were active throughout much of the day, flight commencing during mid-morning and continuing through to late afternoon. More females presented in late afternoon, with a maximum number of males active in early mid-afternoon. Adult behaviour involved courtship refusals, feeding, perching, basking, inspection of the silvery undersides of settled adults and similarly coloured bird dung, and roosting as part of a typical day's activity. Feeding and adult abundance positively correlated with prevailing shade temperatures. Both sexes seemingly favoured shiny leaves on which to perch and preferred moderate heights, males increasing their perch site height later in the afternoon. The aggregation was highly localised, but males occasionally explored adjacent habitat, flying up to 56m from the epicentre. In many ways their varied behaviours parallelled that recorded for other eastern Australian lycaenidae, especially *Hypochrysops* and *Paralucia*, two groups for which detailed observations have been published.

Figure 5. Male *C. consimilis goodingi* at the foraging site on Sector 1 where 'localised feeding phenomena' took place.

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