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TEMPORAL CHANGES IN ABUNDANCE OF TWO LYCAENID BUTTERFLIES (LYCAENIDAE) IN RELATION TO ADULT FOOD RESOURCES

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ABSTRACT. The temporal distributions of adult *Hypochrysops apelles* (F.) and *H. epicurus* (Miskin) in relation to the abundance of flowering mangroves were examined over a 2.5 year period at Redland Bay near Brisbane, Australia. The flight period of both species (September to May) coincided with the flowering of two mangrove species that the butterflies visited for food. Within the flight period of *H. epicurus*, adult abundance was closely associated with the abundance of mangrove flowers over time. Several explanations for the observed relationship are suggested; the most likely causal factors are climate and adult food availability. A laboratory experiment confirmed that the availability of adult food (carbohydrate) could increase longevity in both species.

Additional key words: flight period, nectar, Australia, mangrove *Hypochrysops*.

Shapiro (1975) suggested that a butterfly's flight period depends primarily on the availability of sunshine, nectar, and oviposition sites. Given that these resources are available, predation and competition might then be important. Several studies have related the flight period of particular butterfly species to the availability of either favorable conditions for flight or suitable oviposition sites (Cappuccino & Kareiva 1985, Dobkin et al. 1987, Slansky 1974). However, the importance of nectar availability in determining the flight period of butterflies remains poorly studied.

There are indications that the temporal availability of flowers, together with seasonal and biological factors, may be important in determining the flight period of some butterfly species (Clench 1967, Owen 1971, Owen et al. 1972, Percival 1974, Shapiro 1975). Although these authors suggest that the temporal abundance of butterflies may be tied closely to the abundance of the flowers they utilize as adult food

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resources, their studies often have been based on anecdotal observations of flowering phenology. The aim of this study was to determine whether temporal changes in abundance of *Hypochrysops apelles* (F.) and *H. epicurus* Miskin were related to the temporal availability of their adult food resources. As such, it is one of the few attempts to obtain detailed temporal data on both butterflies and flowers and, while the observed associations are open to several interpretations, they represent a first step in determining whether such relationships exist.

METHODS

The study was conducted at Redland Bay (153°17′E, 27°35′S), situated on the coast of Moreton Bay near Brisbane, Australia. The climate is subtropical, with hot, wet conditions from October to March and mild, dry conditions from May to August. The study area comprised a patch of mangroves with an area of 14.7 hectares. The vegetation at the site is dominated by the mangrove *Avicennia marina* (Forssk.) Vierh (Avicenniaceae), but the mangroves *Rhizophora stylosa* Griff. (Rhizophoraceae), *Ceriops tagal* (Perrottet) C. B. Robinson (Rhizophoraceae), and *Aegiceras corniculatum* (L.) Blanco (Myrsinaceae) also are common.

In the Brisbane region, both *H. apelles* and *H. epicurus* are found only within mangrove habitats. However, at the northern end of its distribution, *H. apelles* occurs in a variety of other habitat types (Common & Waterhouse 1981). The larvae of *H. apelles* feed on the mature leaves of *R. stylosa* and *C. tagal,* although several other plant species have been recorded as hosts elsewhere (Common & Waterhouse 1981). *Hypochrysops epicurus* is restricted to mangrove habitats throughout its range (Common & Waterhouse 1981). The larvae of *H. epicurus* feed on the mature leaves of *A. marina,* which is the most abundant mangrove in the Brisbane region.

The abundance of the butterflies was estimated using a transect walk as described by Pollard (1977). The transect (which incorporated as much intra-habitat variation as possible) was 2100 m long and took an average of 95 minutes to complete. The sampling area was set at 10 m in front, 5 m on either side, and 5 m directly above the observer. Following Moore's (1975) technique, a long-handled butterfly net was waved over the vegetation in order to disturb any perching individuals. In order to encompass the period of maximum adult butterfly activity, observations were performed between 1030 h and 1430 h. To ensure that observations were carried out on days on which conditions were favorable for flight activity, the following criteria were adopted: (i) 50% or less of sample time spent under cloud cover, (ii) average temperature between 17 and 32°C, and (iii) average wind speed of 10 km h^{-1} or less. Any samples that did not fit these criteria were discarded.

The temporal availability of adult food was estimated by counting the number of flowering individuals (i.e., any plant that had flowers present) of all mangrove species for 5 m on either side of the transect. This method provides only a rough estimate of the amount of adult food available but accurately describes the time at which the food is available. In addition, records were kept of any feeding events by any butterfly species.

Sampling commenced in September 1982 and ceased in February 1985. Sampling was conducted once per month from September 1982 to August 1983 and from June 1984 to August 1984. From September 1983 to May 1984 and from September 1984 to February 1985, two sampling efforts per month were conducted.

In addition to the field sampling, a small laboratory experiment was conducted using adult *H. apelles* and *H. epicurus* reared from larvae collected in the field. In this experiment twelve to fourteen adult butterflies of each species were given either a water diet or a diet of 10% honey solution. The butterflies were kept in individual containers at a constant temperature of 25°C and a 12/12 hour light/dark cycle. Only longevity was measured because it was not possible to get either species to mate or lay eggs in the laboratory.

RESULTS

Avicennia corniculatum and *A. marina* were the only species whose flowers were visited by butterflies at Redland Bay. During this study *A. corniculatum* produced flowers from September to December, whereas *A. marina* flowered from January to April.

The temporal distribution of *H. apelles* was variable (Fig. 1). The flight period began in September and ended in May; however, the number of peaks in abundance varied from year to year. While the summer flight period coincided with the flowering of the two mangrove species used as adult food, no clear association between the butterfly and its adult food was observed within its flight period. Figure 2 presents the same data for *H. epicurus*. The flight period of *H. epicurus* commenced in September and finished in May with only two peaks of abundance evident. These peaks coincided with the flowering phenology of *A. corniculatum* and *A. marina*.

These trends are confirmed by correlations (Spearman's rank) between butterfly and flower abundance (Table 1). Both butterfly species were significantly correlated ($P < 0.01$) with flowering mangrove abun-

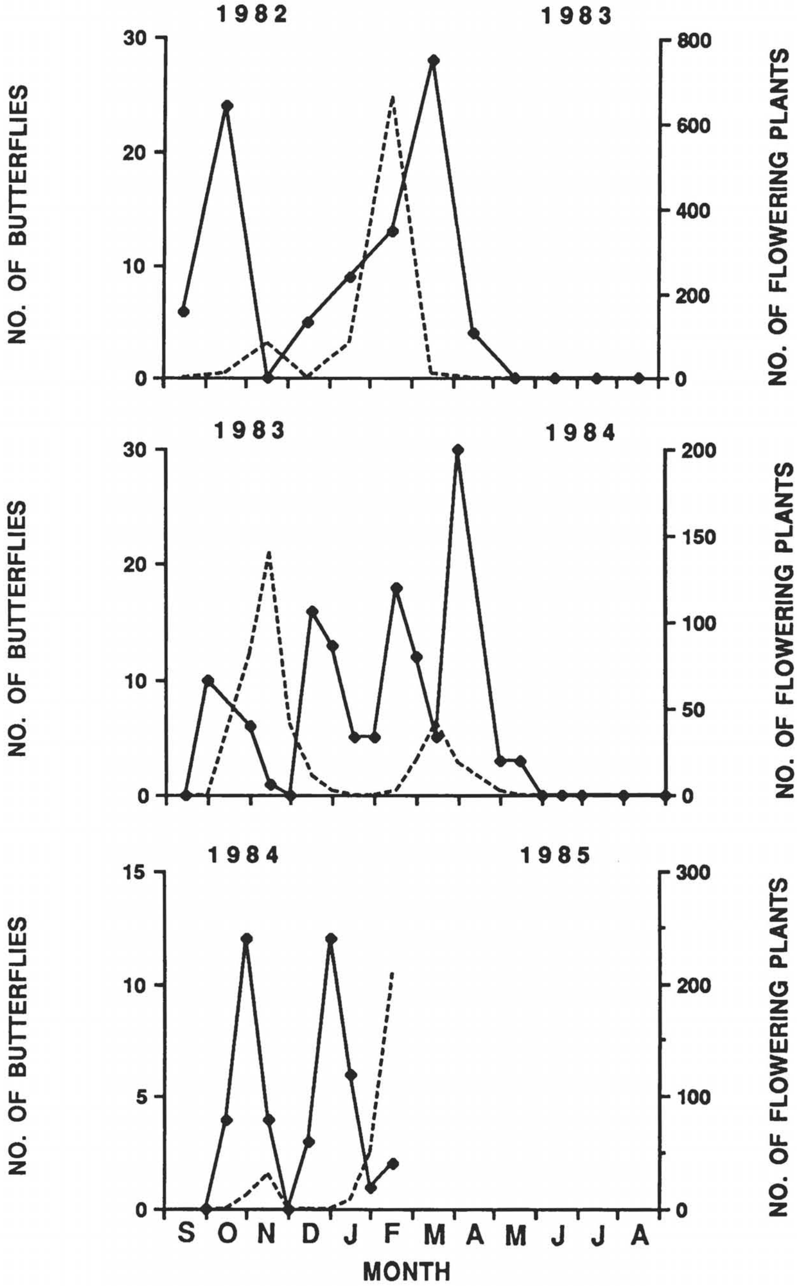

FIG. 1. Temporal changes in abundance of adult *H. apelles* (solid line) and the number of *A. corniculatum* and *A. marina* plants in flower (dashed line) from September 1982 to February 1985.

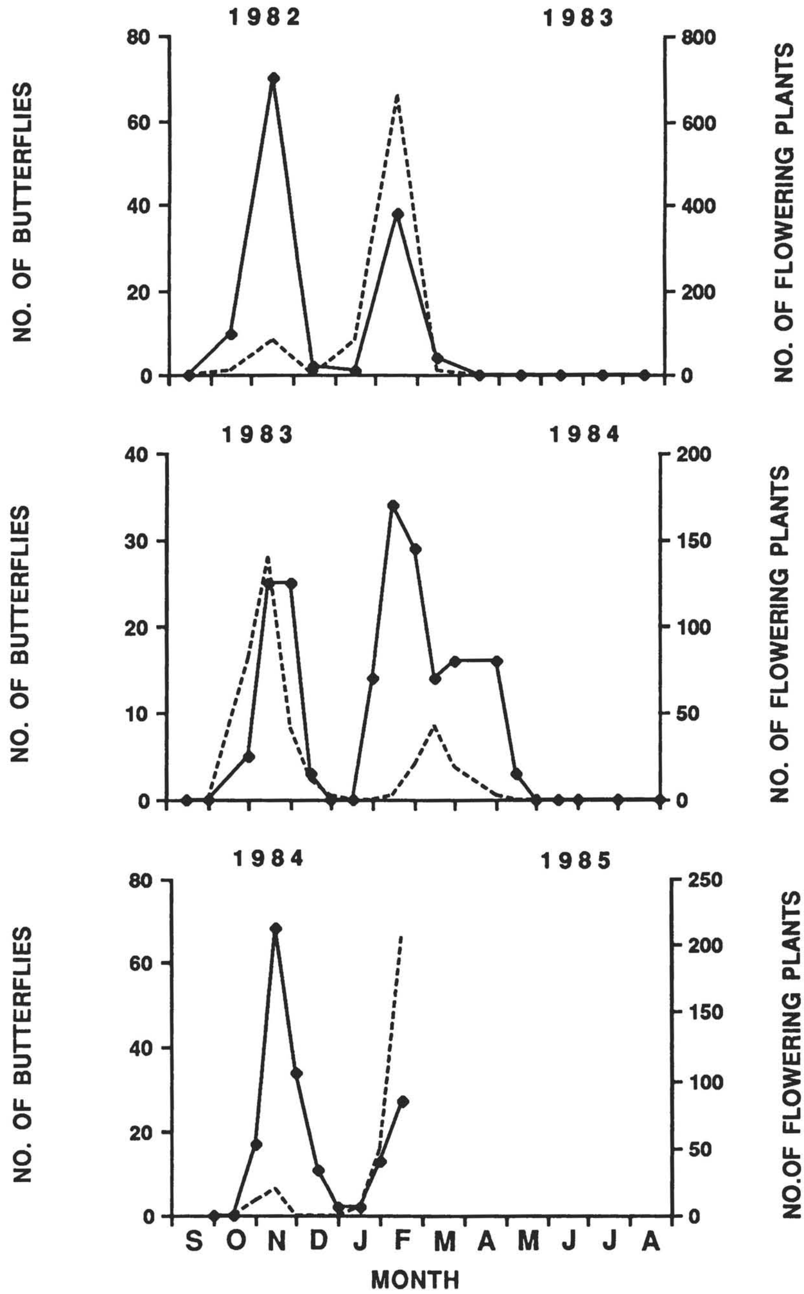

FIG. 2. Temporal changes in abundance of adult *H. epicurus* (solid line) and the number of *A. corniculatum* and *A. marina* plants in flower (dashed line) from September 1982 to February 1985.

TABLE 1. Correlations (Spearman's rank) between the abundance of adult *H. apelles* and *H. epicurus* and the number of flowering individuals of *A. corniculatum* and *A. marina* for samples occurring from September to May within the two complete sampling years and for all samples (NS: not significant; * $P < 0.05$; ** $P < 0.01$).

Species		Sep 1982–May 1983	Sep 1983–May 1984	Sep 1982–Feb 1985
Hypochrysops apelles	r^s	0.46	0.16	0.41
	n	9	16	42
	p	0.211^{NS}	0.559^{NS}	0.008*
Hypochrysops epicurus	r^s	0.68	0.62	0.70
	n	9	16	42
	p	0.042*	0.010*	0.001**

dance over the whole sampling period, indicating that the flight periods of the butterflies and the flowering of the mangrove species occurred in the same season from year to year. *Hypochrysops epicurus* abundance also illustrated a significant statistical correlation ($P < 0.05$) with the number of flowering mangroves within its flight period (September to May). *Hypochrysops apelles,* however, was not correlated with flowering mangroves within its flight period.

The results of the adult feeding experiment are given in Table 2. The availability of honey (carbohydrate and amino acids) in the adult diet greatly increased the longevity of both *H. apelles* and *H. epicurus.*

DISCUSSION

Although closely related and occupying similar habitats, *H. apelles* and *H. epicurus* exhibit different patterns of adult flight activity. Both species occurred as adults during the warmer months suggesting that climate plays a role in determining their flight period. In southeastern Queensland, all known *Hypochrysops* overwinter as mature larvae (D. Sands pers. comm.). Therefore, the start of the flight period in Septem-

TABLE 2. The mean longevity (days) and results of a *t*-test for adult *H. apelles* and *H. epicurus* provided with diets of either water or 10% honey solution.

Species	Diet	Mean longevity	Sample size	*t*-test
H. apelles	Water	3.0	12	6.7
	10% honey	20.2	13	$P < 0.001$
H. epicurus	Water	4.0	14	3.8
	10% honey	14.9	13	$P < 0.001$

ber commences when adults eclose from pupae produced by the overwintering larvae. Subsequent generations of adults result as the season progresses. In the case of *H. apelles*, the number of generations per year was variable, but for *H. epicurus* there were two distinct peaks of adult abundance each year. The close coincidence of the peaks of abundance shown by *H. epicurus* and the flowering of *A. corniculatum* and *A. marina* suggests that their respective phenologies are closely related.

There are three likely explanations for this temporal association between butterflies and flowers. First, the result may simply reflect the movement of butterflies into and out of the study site as flowers go into and out of bloom, as has been found for other species of lycaenids (Douwes 1975, Sharp & Parks 1973, Sharp et al. 1974). However, despite extensive searches of other nectar sources in the vicinity of the study site, neither species was observed outside the mangrove habitat.

Second, it is possible that larval resources in some way account for the observed flight periods. For instance, the nutritional quality of the mature leaves may vary throughout the year. *Hypochrysops epicurus* oviposits on the twigs of its larval food plant, and the larvae feed on mature leaves which are present throughout the year; therefore, this explanation seems unlikely. Alternatively, since the larvae of both species of butterfly are obligately tended by ants (Common & Waterhouse 1981), adult abundance may be related to ant activity. However, the appropriate ant species were observed on the mangroves at all times of the year, often tending overwintering larvae.

The final hypothesis is that the flight period and abundance of adult *H. epicurus* is timed to coincide with the availability of food resources in its habitat. The availability of food to adult butterflies can have important effects on the longevity and fecundity of some species (Leather 1984, Murphy et al. 1983, Norris 1935). The laboratory experiment on the effect of adult diet on *H. epicurus* and *H. apelles* demonstrated that the presence of honey in the diet greatly increased adult longevity of these species. In addition, Hill and Pierce (1989) have shown that the availability of sugar significantly increased both longevity and fecundity of the lycaenid *Jalmenus evagoras* (Donovan). Therefore, by maximizing longevity and fecundity, the availability of adult food has the potential to play an important role in the population biology of butterfly species. However, the temporal association between *H. epicurus* and the flowers on which it feeds may not be caused solely by a requirement of the adult butterflies for the sugars and/or amino acids in floral nectar. Butterfly species that are confined to mangroves are in a unique situation. If adults emerge during a period of the year in which no mangroves are flowering, then there are no alternative nectar sources. Moreover, the mangrove substrate is highly saline and there is no source of water apart from rainfall. Therefore the mangrove flowers are the only predictable source of sugar, amino-acids, and water available to these butterflies. It is possible that the close temporal relationship between *H. epicurus* and flower abundance may be as much due to an avoidance of desiccation as to the availability of floral nectar as adult food. Watt et al. (1974) have stated that water may be as valuable a resource as nectar or excess pollen to flower visitors. In this respect, it is significant that the lycaenid butterfly *Acrodipsas illidgei* (Waterhouse and Lyell), another mangrove specialist found at the same site, is recorded as having a flight period from September to December and in February (Common & Waterhouse 1981, C. Hill unpubl. obs.). Thus, the flight period of this species coincides with the flowering times of the two mangrove species that are the major source of adult food for butterflies in this habitat. Even though *A. illidgei* are autogenous and do not require nectar to reproduce (Sands 1980), the availability of nectar might extend the longevity of adults.

In contrast to *H. epicurus, H. appeles* showed no close temporal association with its adult food. It may have alternative food sources that were unidentified in this study. Primack and Tomlinson (1978) have shown that *R. stylosa*, the larval food plant of *H. apelles*, secretes a sugar solution from its terminal leaves, but butterflies were not observed feeding on this secretion in this study. Alternatively, *H. apelles* may possess a life history strategy in which larval reserves provide sufficient energy throughout the length of the adult life.

To demonstrate unequivocally a temporal association between the flight period of a butterfly and the flowers that it uses as adult food resources requires the collection of several seasons' data in order to determine whether a pattern exists. The two and a half years' data collected in this study suggest that, for *H. epicurus*, the flight periods of the butterfly do coincide with the flowering of the mangroves that it uses as food. In addition, a laboratory experiment showed that the presence of sugar in the adult diet increased longevity. To test further this hypothesis would require some manipulation of the availability of adult food resources in the butterfly's habitat. Decreasing the temporal availability of adult food resources by removing key plant species would be an informative way to test such an hypothesis but also would be prohibitively destructive.

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