The effect of adult diet on the biology of butterflies

1. The common imperial blue, Jalmenus evagoras

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Summary. This study examines the effect that sugars and amino acids in the adult diet of Jalmenus evagoras can have on female feeding behaviour, somatic maintenance, longevity, fecundity and egg weight. The presence of sugars in their adult food stimulated butterflies of this species to feed, and they appeared to compensate for low (1% wt/wt) sugar diets by feeding for longer periods. Butterflies were also more likely to feed on diets containing amino acids than on water controls. The availability of sugar allowed females to maintain or even increase their body weight and fat body size, but amino acids had no effect on these variables. Individuals on the medium (25% wt/wt) sugar diet attained the greatest longevity. Female fecundity was increased as much as threefold by the availability of sugar. However, amino acids in the diet had no effect on either longevity or fecundity. Egg weight was not affected by the concentration of sugars or amino acids in the adult diet, but was correlated with the weight of the female butterfly. These results demonstrate that the availability of carbohydrates in the adult diet could play an important role in the population dynamics of this species. However, the presence of amino acids had little effect on most of the variables measured, nor was there any interaction effect between sugars and amino acids.

Key words: Adult diet – Jalmenus evagoras – Butterfly biology – Longevity – Fecundity

Most field studies of butterfly population biology have concentrated on mortality in the pre-adult life history stages of the butterfly (see Dempster 1984; Ehrlich 1984 for review). However studies by Courtney and Duggan (1983) and Hayes (1981) have found that egg shortfall due to insufficient oviposition time can be a key mortality factor (sensu Varley et al. 1973) for some species. Climatic conditions that are adverse for flight activity have been suggested as a primary cause of egg shortfall, but other factors may also affect both the length of time which a butterfly has to lay its eggs and the number of eggs which it has available to lay. One such factor, the availability of adult food re-

sources, has long been known to influence both the longevity and fecundity of certain butterfly species (Norris 1935; Stern and Smith 1960; David and Gardiner 1962; Murphy et al. 1983). However, most of these studies have examined only the effect of sugars in the diet, and all of them used only a limited range of concentrations. Gilbert (1972) first described pollen feeding by Heliconius butterflies, and subsequently Dunlap-Pianka et al. (1977) showed that the availability of pollen (as a source of amino acids) in the adult diet greatly increased egg production in these butterflies. Baker and Baker’s (1973a) discovery of relatively high concentrations of amino acids in the nectar of butterfly pollinated flowers has led to an interest in the importance of amino acids in the adult diet of Lepidoptera. Few studies so far have attempted to determine the importance of amino acids in floral nectar. Murphy et al. (1983) found that amino acids had a beneficial effect on egg weight of Euphydryas editha, although Moore and Singer (1987) were unable to replicate this result. The aim of this study is to determine whether the composition and concentration of the sugars and amino acids in the adult diet of the Australian lycaenid butterfly, Jalmenus evagoras affect the longevity, fecundity, somatic maintenance and egg weight of females of this species.

Materials and methods

The species

Jalmenus evagoras (Donvan) is a locally common lycaenid of the eastern coast of Australia. The source of the individuals used in this study was a population at Mount Nebo near Brisbane which has been studied extensively over a number of years (Kitching and Taylor 1981; Kitching 1983; Pierce and Elgar 1985; Pierce et al. 1987). On hatching, the first instar larvae were transferred to potted Acacia spectabilis, one of several species of Acacia that have been recorded as food plants of J. evagoras (Common and Waterhouse 1981), and reared in a greenhouse at 28°C. Although in the field the larvae of this species are always tended by ants in the genus Iridomyrmex, they can be reared successfully without ants in the laboratory as was the case in this study. The larvae were allowed to pupate on the host plants and were then transferred to a 60 cm³ mating cage. Mating pairs were removed from the cage and remained isolated until mating was completed.
Amino acids

In this study the six amino acids used were alanine, arginine, glycine, lysine, proline and serine. These amino acids are among those which commonly occur in the nectar of flowers which are visited by butterflies (Watt et al. 1974; Baker 1976). It should be noted that, given the number of naturally occurring amino acids, the amino acids selected for this study may not fulfil the nutritional requirements of *J. evagoras*. The concentration of amino acids in butterfly-visited flowers ranged from 1.0 to 5.0 mM (Baker and Baker 1973b; Watt et al. 1974; Heyneman 1983). In this study three levels of amino acid concentration were used. The medium concentration was set at 1.0 mM, the high and low concentrations were 10 mM and 0.1 mM respectively.

In summary, the composition of the sugars and amino acids in the artificial diets were selected to fall within the range of those found in the floral nectars of butterfly pollinated flowers. The medium concentration levels of sugars and amino acids approximates those found in the floral nectar of butterfly pollinated flowers. Therefore treatment 5 most closely resembles floral nectar. The high and the low concentration levels were selected with respect to the values chosen for the medium concentration level.

The variables measured

Feeding behaviour. Female *J. evagoras* would not feed normally under laboratory conditions, therefore each butterfly was fed twice daily on 0.5 cm³ of the appropriate food solution from a plastic test tube cap. No attempt was made to force feed the butterfly, each individual was simply placed on the food solution up to three times. The number of times a female fed each day was recorded. This variable was called the ‘feed status’ and had values of either 0, 1 or 2. In addition, the time spent feeding was recorded for some individuals during the course of the experiment.

Longevity

The eclosion date and date of death were recorded for each butterfly, to provide a measure of longevity.

Fecundity

At the end of each day (1700hrs) all eggs laid by an individual were removed from the oviposition chamber, counted and weighed. The eggs were weighed as daily batches, to give a mean daily egg weight for each individual. In addition each female was dissected after death and the number of mature (i.e. chorionated) eggs present in its ovaries were counted. This procedure has been used in other studies of this type (Stern and Smith 1960; Leather 1984). The sum of the eggs laid and the mature eggs present on death was used as the total number of eggs for each female. The presence of mature eggs on the death of the female, particularly in long-lived individuals, suggested that not all individuals were stimulated to oviposit in the experimental containers. There was considerable variation in this respect, some individuals did not oviposit at all whereas others laid all their eggs.

Somatic maintenance

As soon as possible after death, each female butterfly was weighed and this value, together with its weight at eclosion,