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TEMPERATURE INDUCED SEASONAL MELANISM IN THE WINGS OF *COPAEODES MINIMA* (LEPIDOPTERA: HESPERIIDAE)

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ABSTRACT

The effects of photoperiod and temperature on wing coloration in the skipper *Copaeodes minima* (Hesperiidae) was studied in the laboratory. Individuals reared in incubators at 20°C had a higher proportion of darkened scales along a transect on the dorsal surface of the secondary wings than individuals reared at 30°C. Photoperiod (10h vs. 16h light) did not affect patterns of scale coloration.

RESUMEN

Los efectos de temperatura y de fotoperíodo en la coloración de alas de la mariposa *Copaeodes minima* (Hesperiidae) fueron estudiados bajo condiciones de laboratorio. Los individuos criados en incubadoras a 20°C, mostraron una mayor proporción de escamas ennegrecidas a lo largo de un transecto en la superficie dorsal de las alas secundarias, que los individuos criados a 30°C. El fotoperíodo (10h vs. 16h de luz) no modificó los patrones de coloracion de las escamas.

Lepidopteran seasonal melanism is the occurrence of light-colored adults during the summer and of darker adults during cooler times of the year. It arises in response to variations in environmental conditions during larval and pupal development. For a review of seasonal melanism and other polyphenisms see Shapiro (1976).

Little work on seasonal melanism has been done for species in the family Hesperiidae. Ishi (1977) worked with the rice plant skipper, *Parnara guttata guttata* and determined that temperature and not photoperiod during development is the principal factor determining the degree of melanization in pupae. Ishi (1977) obtained dark pupae by rearing larvae at 20°C or colder. He found 22.5°C to be the critical temperature that produced variously pigmented (intermediate) pupae while 25°C and warmer temperatures yielded ivory pupae. He did not investigate the effects of temperature on adult color.

Reported here are the effects of photoperiod and temperature during development on the color of *Copaeodes minima* (Hesperiidae), a multivoltine skipper present in southern Florida throughout the year. Adult *C. minima* active during January, February and March have darkened scales on the dorsal surface of the secondary wings next to the abdomen (Lewis 1984). Additionally, some scales are darkened on the ventral surface of the secondary wings. Adults active during warmer times of the year have fewer or no melanic scales in these areas (Lewis 1984). The present laboratory study investigated the environmental factors that give rise to this pattern.

Materials and Methods

Quantification of wing color:

The dorsal wing scales were subjectively classed as light (gold) or dark (black). The degree of melanization on the dorsal surface of the secondary wings of each individual was quantified by counting the number of scales of the two color classes that touched a 2.5mm line transect. A dissecting microscope was used for this purpose. The transect ran between the base of the A_3 vein and the inner margin of the wing (Fig. 1).

Data were presented as the percentage of the total number of scales counted that were melanized for each individual in each treatment. These data were analyzed using the median test (Conover 1971).

Controlled environment experiment:

Adult female *C. minima* were captured in Dade County, Florida, between April and November in both 1981 and 1982. Each female was kept in a separate cage that contained bermuda grass (*Cynodon dactylon*), the normal larval food plant, rooted in vermiculite. Cages were made of 17-mesh screen stapled to form an open-ended cylinder (8cm in diameter, 5cm long). The cylinders were inserted in deep petri dishes containing the bermuda grass and were covered with petri dish bottoms. Females readily deposited eggs on the bermuda grass inside an environmental chamber (16h photoperiod at 30°C).

Each female's eggs were randomly distributed equally among the following four treatments; 1) (long day, 16h; low temperature, 20°C); 2) (short day, 10h; low temperature, 20°C); 3) (long day, 16h; high temperature, 30°C); 4) (short day, 10h; high temperature, 30°C). Larvae were transferred to new cages of bermuda grass every 3 days until pupation. The environmental chambers each had a volume of 196.7 liters and were illuminated by two 20-watt cool-white fluorescent lamps delivering 80 microeinsteins of energy at the level of the cages. The chamber thermostats were calibrated using a Bailey Bat-9 amplifying thermometer. A recording hygrothermograph also monitored the temperature and humidity in each chamber. Pupae were kept in cages without bermuda grass inside the chamber of their larval development until adult emergence.

Results and Discussion

Dorsal wing scale melanization affects only the proximal portion of the leading edge and the area adjacent to the inner margin of the secondary wing. The remaining dorsal

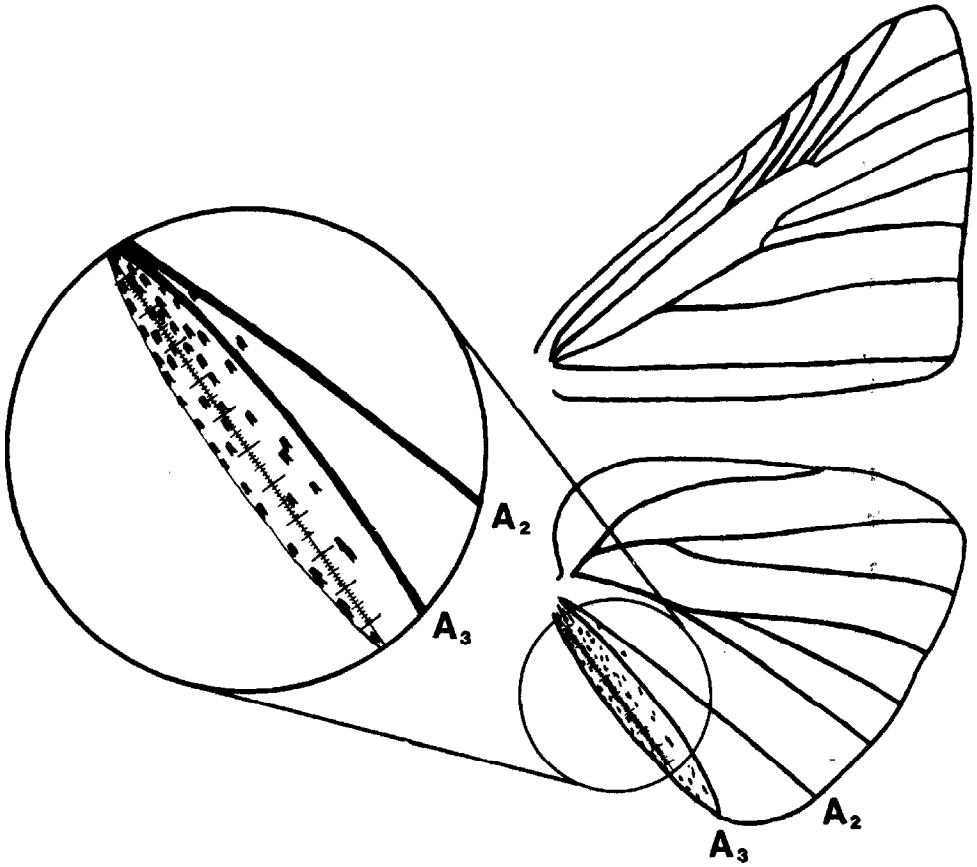

Fig. 1. Dorsal surface of *C. minima* primary and secondary wings. The circle shows a 40X magnification of the area viewed through the dissecting microscope in counts of wing scales. A_2 and A_3 refer to the $Anal_2$ and $Anal_3$ veins of the secondary wing. The line forming the transect is part of the ocular micrometer of the microscope. The transect is 2.5mm long (the length of the micrometer scale at 40X magnification).

wing surfaces are covered with gold scales in males, while females have dark scales covering the veins on both surfaces.

The percentages of dark scales ranged from 3 to 100% for counts made on the dorsal wing surfaces of 53 individuals (Fig. 2). Those individuals reared at the lower temperature (20°C) in treatments 1 and 2, under the 16h and 10h photoperiods, had similar, high median percentages of darkened scales (Treatment 1, median = 82.0%; Treatment 2, median = 75.8%). In the high temperature treatments (Treatments 3 and 4), the median percentages of dark scales were similarly low at both the long and short photoperiods (27.2 and 37.1%, respectively). The median percentages for individuals reared at the lower temperature are higher than those for individuals reared at the higher temperature, under both photoperiods; that is, the wings of the low temperature treatments are darker than those from the high temperature treatments.

The Median test (Conover 1971) was used to examine whether or not the distributions of percentages of darkened scales from the four treatments have the same median. The null hypothesis that all four treatments resulted in the same median percentage of darkened scales is rejected ($\chi^2 = 24.7$, d.f. = 3, $p < 0.05$).

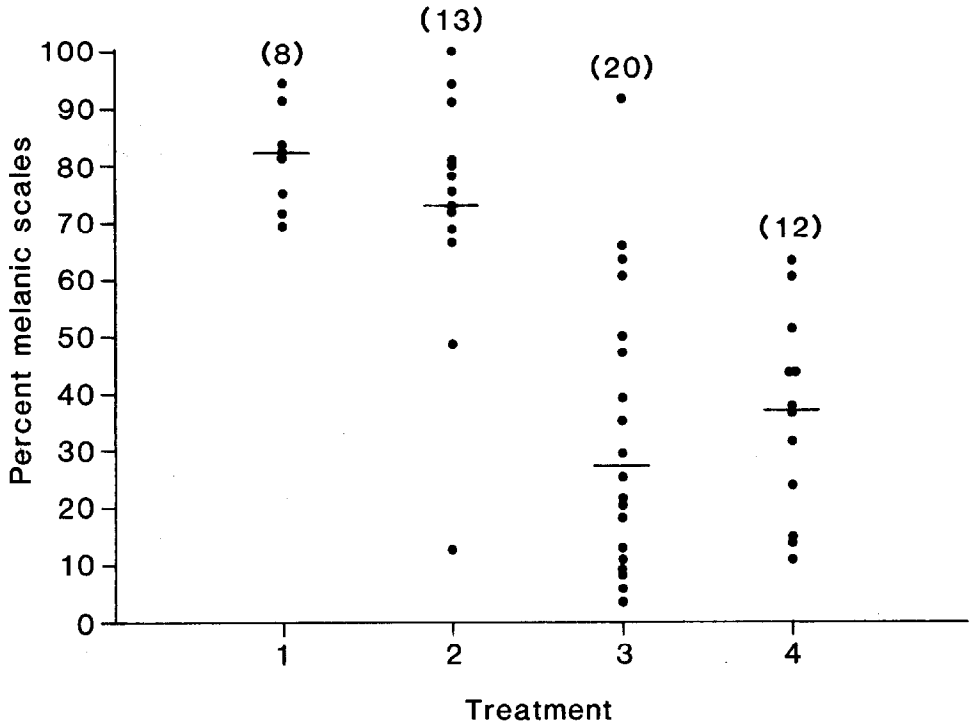

Fig. 2. Percentage of dark scales on the cell formed by the A_3 vein and the inner wing margin of the dorsal wing. Each point represents a single skipper. The horizontal line indicates the median percentage for that treatment. (Treatments: 1 = long day, low temperature; 2 = short day, low temperature; 3 = long day, high temperature; 4 = short day, high temperature).

The relative effects of temperature and photoperiod were examined separately in subgroups of the original data. The sorting procedure distorts the true level of significance (Conover 1971). Therefore, I modified the level for rejection of the null hypothesis to $p = 0.0253$ according to the formula $p' = 1 - (1 - p_o)^{1/k}$; where p' = the modified significance level, p_o = the a priori significance level = 0.05, and k = the number of times the data are regrouped (Sokal and Rohlf 1981).

To examine the effects of temperature on the darkening of scales, the data for treatments 1 and 2 (low-temperature group) and treatments 3 and 4 (high-temperature group) were combined. The Median test was performed to test the null hypothesis that the median percentages of dark scales for the high and low-temperature groupings are equal. The null hypothesis is rejected ($\chi^2 = 21.2$, d.f. = 1, $p < 0.0253$). The effects of photoperiod are examined in a similar fashion by combining the data from treatments 1 and 3 to form a long-day (16h) group and treatments 2 and 4 to form a short-day (10h) group. The results indicate no effects of photoperiod on the percentage of scales that are darkened. The null hypothesis that the medians are equal is not rejected ($\chi^2 = 0.07$, d.f. = 1, $p > 0.0253$). The results demonstrated that, at the particular temperatures and photoperiods used in this study, only temperature affects the degree of darkening of the dorsal surface of the secondary wing; the percentage of scales that is darkened is greater at 20°C than at 30°C.

Although temperature is an important proximal cue influencing wing coloration, several questions about its effects remain unanswered. In this study temperature and

photoperiod were held constant. In nature, of course, temperatures can vary drastically both within a day and among days. It may be that dark skippers result when a certain proportion of development time is below some critical temperature, or when the mean of all temperatures is below some critical temperature, or perhaps when a single, however short, sufficiently cold period occurs. There may be a number of other possibilities. Carefully designed, rigorous experiments are needed to determine the precise mechanism.

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