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BODY WEIGHT AND WING LENGTH CHANGES IN MINNESOTA POPULATIONS OF THE MONARCH BUTTERFLY

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ABSTRACT. Body weights and rear wing lengths were obtained from about 1900 monarch butterflies captured near Minneapolis, Minnesota, during the past decade. Mean values for both were lowest in immigrants and highest in subsequent generations. Mean wing length was highest in males. Mean body weights of immigrant females were higher than those of males, but mean male body weights were higher than those of females in subsequent generations. The data argue against the return to Minnesota of emigrants from the previous year, and suggest that attainment of large adult size could be one reason for monarch migration to northern regions.

Additional key words: Nymphalidae, *Danaus plexippus*, migration, sexual differences.

During the past several years workers in my laboratory have examined various aspects of the biology of the monarch butterfly, *Danaus plexippus* L. Our studies have impressed us with the great variation exhibited by monarch populations in our locality with respect to reproductive status, hormone titers, behavior, and other variables (Herman 1985). Monarch butterflies of both sexes also exhibit predictable changes in body weights and wing lengths during their residence in our area, and such changes are the topic of this report.

MATERIALS AND METHODS

Animals used for this study were captured near Minneapolis, Minnesota, between 1976 and 1986. They were taken to the laboratory for measurement soon after capture, usually within a few h. Whole-body wet weights were determined to the nearest 1 mg using an analytical balance, and rear wing maximal lengths were measured to the nearest 0.5 mm with a ruler. Immigrant butterflies rarely arrive in our locality before 15 May, and most local monarchs emigrate by late September. The results are therefore for animals captured 16 May to 15 September, and data in Fig. 1 are summarized for 2-wk and 2-mo intervals during that period. All data are presented as mean ± standard error; statistical analysis was done using Student's t-test.

RESULTS

Mean wing lengths for both sexes were smallest during the 2-mo period 16 May–15 July (Fig. 1). Most of these animals were presumably immigrants from southern regions, since large numbers of monarchs

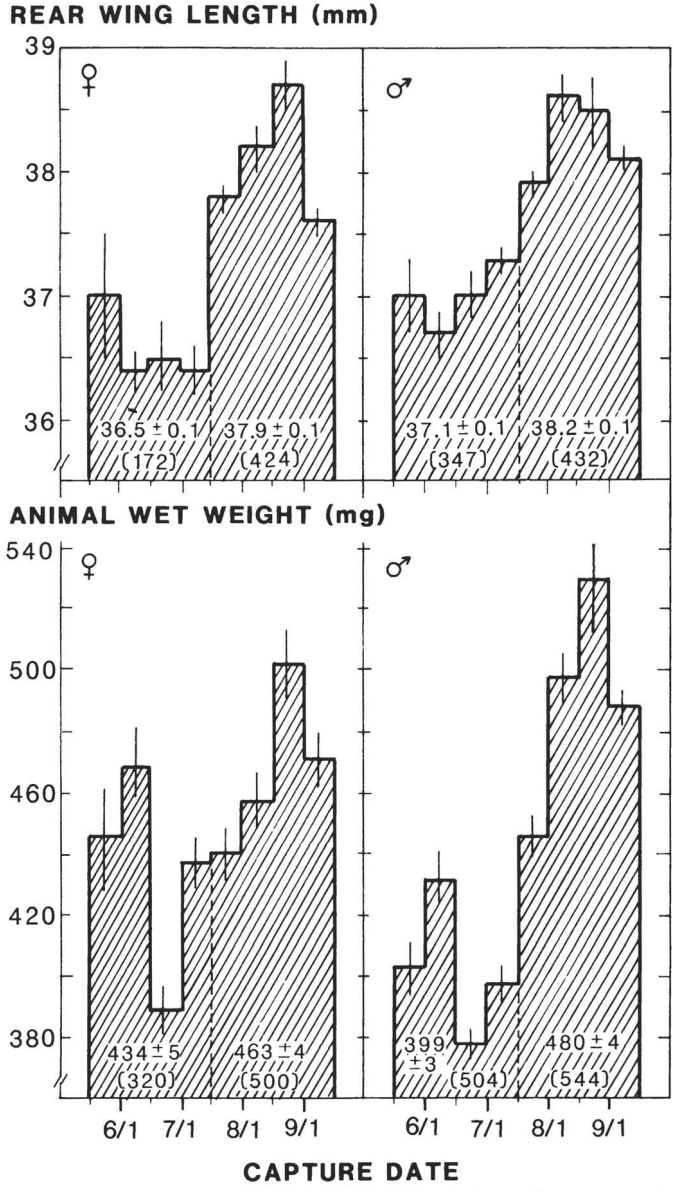

FIG. 1. Wing lengths and body weights of monarch butterflies captured near Minneapolis, Minnesota, 16 May–15 September. Data are summarized for 2-wk and 2-mo periods. Means for 2-mo periods are shown numerically, and number of individuals given in parentheses. Vertical lines indicate SE.

do not typically emerge in our area until early July. Mean wing length in both sexes increased significantly ($P = 0.001$ for both sexes) in the 2nd 2-mo period 16 July–15 September. Presumably, most of the latter animals emerged in our locality. Mean female wing length increased 3.8% in the second 2-mo period, that of males, 3.0%. Mean male wing lengths were significantly larger than those of females in both the 1st ($P = 0.001$) and 2nd ($P = 0.05$) 2-mo periods. Mean wing lengths recorded 16 July–15 September were indistinguishable from those observed at emergence in monarchs reared on milkweed, *Asclepias syriaca* L., in our area in July and August: 37.8 ± 0.1 mm ($n = 100$) and 38.0 ± 0.1 mm ($n = 83$) for females and males, respectively, on the day of eclosion. Rear wing length varied from 29.5 to 42.0 mm in this study, and both extremes were observed in males.

Body weights of both sexes changed in a manner similar to that of wing lengths, with low mean values characterizing the mainly immigrant populations of 16 May–15 July, and significantly higher mean values observed in monarchs that had presumably emerged in our area 16 July–15 September (Fig. 1). Mean body weights for females were elevated 6.7% in the 2nd 2-mo period, those of males, 20.3%. Mean female body weights were significantly larger ($P = 0.001$) than those of males 16 May–15 July, principally due to higher female weights of 16 May through 15 June. Male values were significantly higher ($P = 0.005$) than those of females during the final 2-mo period. The lowest mean values for both sexes were recorded in late June, when senescence and death of immigrants is most pronounced, and the highest were recorded in late August, when reproduction generally ceases in our area. The increasing mean weights for both sexes from 1 July to 15 August were recorded for populations consisting principally of actively reproducing monarchs of various ages. Mean body weights of wild-caught butterflies never reached the mean values (680 ± 32 mg [$n = 26$] and 652 ± 11 mg [$n = 109$], respectively) measured on day of eclosion for females and males reared in our area. Body weights ranged from 195 to 836 mg during this study, and both extremes were again found in males.

DISCUSSION

The data show that predictable variations occur in rear wing lengths and body weights during the period that monarch butterflies reside near Minneapolis. Small wings and low weights characterize the immigrant population, and both parameters increase significantly in both sexes when monarchs that have apparently emerged in our area predominate in the local population, as they normally do after 1 July. Causes of these variations, and their possible adaptive value, are un-

determined. However, the data suggest that local environmental factors (nutrient value of foodplant, temperature, or photoperiod) during June, July and August may provide optimal conditions for larval growth, and thereby result in larger adults with longer wings. If so, suboptimal conditions for larval development of the presumed immigrant generation in southern areas could account for reduced size in immigrant butterflies. This line of reasoning implies that northward migration in spring could be, to at least some extent, an adaptation for locating regions that optimize adult size. Larger adults may have a greater probability of successful southward migration, survival in the overwintering colonies, or remigration.

The smaller wings of immigrants might somehow facilitate northward migration, while the larger wings of animals emerging in late August and September may be more advantageous for southward migratory flights. Perhaps larger wings are more efficient for soaring and gliding, phenomena reported only for monarchs migrating south (Gibo 1981). Immigrant males with smaller wings might also be more successful at mating, as reported for males in Mexican overwintering colonies (Van Hook 1986). James (1984) noted no significant differences in wing lengths of Australian monarchs observed during a full year.

The data on monarch body weight generally agree with those in other reports (Cenedella 1971, Brown & Chippendale 1974, Brower & Glazier 1975). Other studies have reported significantly higher body weights of males in southward migrating and overwintering monarch populations (Tuskes & Brower 1978, Chaplin & Wells 1982). However, others have apparently not observed periods in the monarch annual cycle when females are significantly heavier than males, as Fig. 1 records for immigrants to our area.

Data in Fig. 1 argue against the return to our locality of monarchs that emigrated the previous year. Our immigrants, especially females, have intermediate weights, and, based on body weight and external appearance, most appear to be young or middle-aged, certainly not old. Immigrants to our area also exhibit both senescence and precipitous weight loss (Fig. 1) within 2–4 wk after arrival, and it seems reasonable to assume that comparable rates of aging and weight loss occur after monarchs leave Mexican overwintering colonies. In view of these observations, it is unlikely that overwintering monarchs could leave Mexican colonies in mid-March (Norman 1986), fly northward for 8–10 wk while actively breeding, and arrive in our area with body weight and external appearance comparable to young populations of July. Similarly, smaller wings of our immigrants suggest they are not members of the emigrant generation of the previous year, since emigrants have significantly larger wings. In addition, monarchs captured in Mexican col-

onies in February and March 1984 had wings comparable in length to our emigrants, and significantly larger than those of our immigrants (Herman unpubl.). For these reasons, the data support an earlier conclusion (Herman 1985), and that of Malcolm et al. (1986), that most immigrants to the northern United States are probably one generation removed from individuals forming Mexican overwintering colonies.

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