

GENERAL NOTES

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BODY WEIGHT AS RELATED TO WING MEASURE IN HAWKMOTHS (SPHINGIDAE)

Forewing or hindwing length (L) and forewing span (S) are often used as species body-size indices in Lepidoptera, but the body weights (W) actually represented are not usually known. Establishing mathematical relations between total body weight or mass and wing measure among species of a taxon not only validates the use of wing measure as a body size surrogate (Miller 1996), but also enables estimation of body weight from wing measure for physiological and ecological purposes. In detail, such relations are specific for different groups; in form, they are usually allometric power functions of $W = a (L^b \text{ or } S^b)$ or the logarithmic equivalent (Miller 1977). Wing length is defined here as the distance between the wing base (excluding tegula) and the farthest extending wing tip (including fringe); wing span is defined as the farthest distance between the wing tips on specimens spread in the usual manner.

In their studies of flight mechanics, Bartholomew and Casey (1978) and Casey (1976) assembled and tabulated W and L values for 15 and 38 identified hawkmoth species, respectively. Although they did not derive relations between W and L in the foregoing papers, Casey (1989) presented such a relation later. This relation had L rather than W as the dependent variable, was based on only the smaller of the above data sets, and was displayed on

Live body wt. (g) (W)

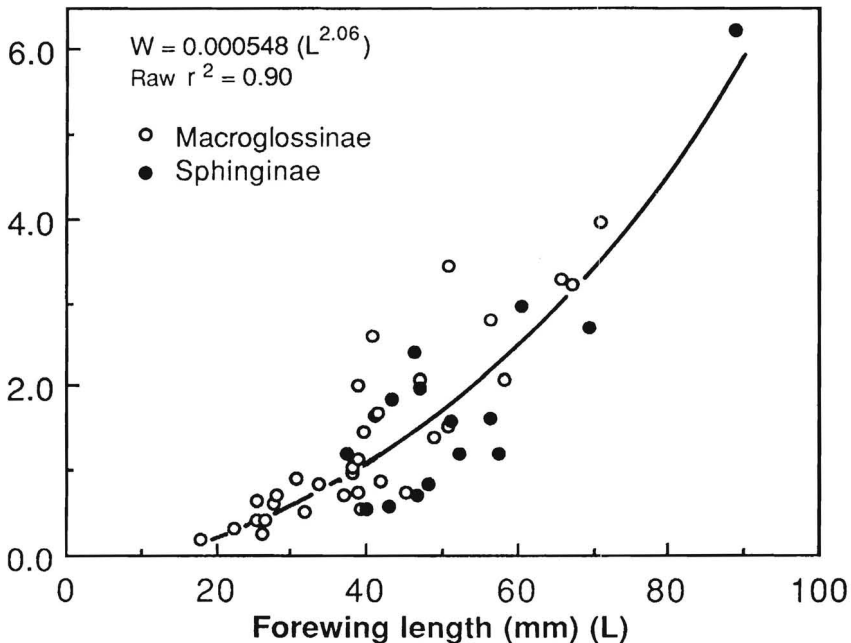


FIG. 1. Live body weight as related to forewing length in hawkmoths. Each point represents from one to several individuals of either or both sexes of a species. Data from Bartholomew and Casey (1978) and Casey (1976).

a double-logarithmic scale. Here I recharacterize the relation with W as the dependent variable using both of the above data sets and displaying results on an arithmetic scale.

Study data here are 70 observations on live weight (W), forewing length (L), and forewing span (S) of field-caught individuals of 48 identified species (Bartholomew & Casey 1978, Casey 1976). These species include 33 Macroglossinae and 15 Sphinginae—the sole subfamilies recognized in Sphingidae (Hodges 1971, Pittaway 1993)—and there are 29 New World and 19 Old World species. The sexes are pooled because many individuals originally were not sexed. Species live weights range from 0.18 to 6.25 g, essentially the full range for the family. For display, two or more observations for the same species were averaged. In analysis, species means were weighted by the number of observations. Where only S was originally given for a species, as in the data set of Casey (1976), I derived L after measuring L and S on D'Abrera's (1986) life-size illustrations such that $L = S(L_{D'Abrera}/S_{D'Abrera})$. To solve the equation $W = a(L^b)$, I used the quasi-Newton loss function for ordinary least-squares nonlinear regression (SYSTAT 1992). I derived proportionality functions for interconverting L and S by simple ordinary least-squares regression.

The recharacterized family-level relation between live body weight (W) and forewing length (L) is $W = 0.000548 (L^{2.06})$ (Fig. 1). It is evident from Fig. 1 that sample species of Sphinginae are larger in mean size than those of Macroglossinae, an outcome that may reflect a real condition among hawkmoths. The subfamilies do not seem to differ in the W versus L relation, however. The proportionality functions which serve to estimate L from S and vice versa when one or the other measurement is available but the other desired are $L = -1.09 + 0.467 S$, and $S = 4.46 + 2.094 L$ ($r^2 = 0.98$).

This study reconfirms that hawkmoth body weight is indexed by wing measure. Live body weight increases as the square of forewing length in Sphingidae, whereas it increases as the cube in Tortricidae (Miller 1977). The difference is fundamental, and reflects the empirical nature of such relations and their dependence on morphometrics and physiology.

Live weights estimated from the nonlinear equation with forewing length (Fig. 1) are not intended for rigorous use. Rigorous use would require not only confidence intervals for the equation, but also body-weight controls in the original sources for sex, egg load, and crop content.

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