

Estimation of dung beetle biomass (Coleoptera: Scarabaeoidea)

JORGE M. LOBO

Museo Nacional de Ciencias Naturales, C.S.I.C., U.E.I. de Entomología,
c/José Gutiérrez Abascal 2, 28006 Madrid, Spain**Biometrics, biomass estimation, length-weight relationships, Scarabaeoidea, dung-beetles**

Abstract. The length-to-body weight relation in specimens of 30 species of Scarabaeoidea coprophaga was calculated, to enable biomass to be estimated from information about body length. The relation proves as the literature predicts, to be a power function. When the species are grouped according to size and body shape, however, it seems that a linear relation may also provide good biomass predictions on the basis of length.

Introduction

Taxon-specific regression equations, which apply a power function to measurements of body weight and length, have been used for some time (Thompson, 1917; Huxley, 1924) to provide reliable estimates of the biomass of different insect families (Rogers et al., 1976; Rogers et al., 1977; Marcuzzi, 1987; Jarošík, 1989; Wenzel et al., 1990). The log-log or power regression has the form: $\ln(Y) = a + b \ln(X)$. However, it was found that the logarithmic transformation used in regression has the effect of decreasing the contribution of larger specimens more than that of smaller ones. Therefore, the use of iterative non-linear regression techniques (Tausch & Tueller, 1988), or of a correction factor (Sprugel, 1983), has been proposed.

The present paper is a contribution toward establishing a log-log regression technique for adult dung-beetles. In order to eliminate the bias resulting from log transformation, the results were compared with those obtained by a linear regression applied to untransformed data, allowing thus for variations due to body shape.

Methods

All specimens belonged to 30 species of the Scarabaeidae (14 species), Geotrupidae (9 species) and Aphodiidae (7 species) families, and were collected from alpine grassland biomes in the "Sierra de Gredos" (Iberian Central System). They were measured using an ocular micrometer ($n = 10$; $s.d. = 0.01$ mm), dried at 60°C, and weighed. The weight of the smaller species (*Onthophagus* and *Aphodius*) was taken to be the mean weight of the 30 adults of each species measured. The range in length was from 4.71 to 30.19 mm, the range in weight was from 2.1 to 764.3 mg.

The statistical significance of the regression is usually determined by computing the correlation coefficient (r), or by determining a t -statistic for b . However, a direct comparison using the standard error (S_{yx}) of the estimated values gives more accurate results (Snedecor & Cochran, 1981; Tausch & Tueller, 1988).

Results and Discussion

The power function for the 30 species shows the usual length-weight relationship (Fig. 1), although the slope of the regression ($b = 3.316$) is greater than that characterising Carabidae ($b = 2.639$; Jarošík, 1989), Tenebrionidae or Curculionidae ($b = 2.681$ and $b = 3.050$, respectively; Rogers et al., 1977), or insects in general ($b = 2.62$; Rogers et al., 1976). The increase in weight with increased length is greater here than in

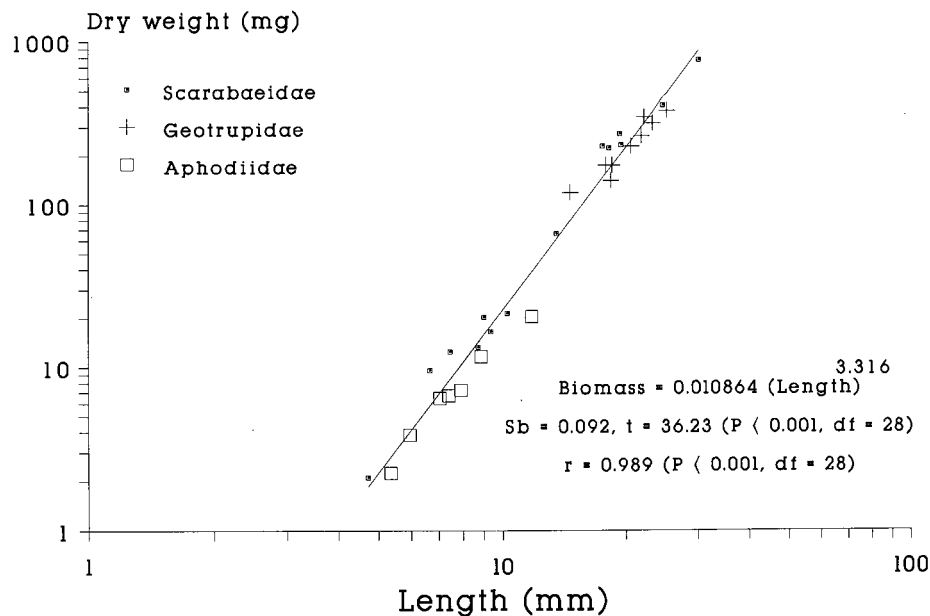


Fig. 1. Length-weight relationship and the power function for the 30 species of dung-beetles.

other families of beetles. However, the high values of this slope are not aberrant, if one takes into account the weight-length relation established for different families of beetles (Marcuzzi, 1987). Some of the causes of this high slope regression could be: the generally round shape of these beetles (more surface/volume relation); three morphometric plains (Lobo, 1992); and the large average body size of certain species, and, therefore, the greatest weight being possibly due to the thickness of the exoskeleton.

When the length-weight relation was plotted for the smaller species (length < 12 mm, 7 Scarabaeidae and 7 Aphodiidae), linear regression also provided a good predictor of the biomass for both families (Fig. 2). This is evident from the lower standard error of the estimated values in the linear regressions of Aphodiidae (power function: $S_{yx} = 8.27$ mg, linear function: $S_{yx} = 0.93$ mg) and Scarabaeidae (power function: $S_{yx} = 3.55$ mg, linear function: $S_{yx} = 2.09$ mg). The predictive quality of linear regression was also evaluated by comparing estimated and actual biomass values. A χ^2 test failed to reject the null hypothesis, indicating that there were no significant differences between the predicted and the real values for the smaller species ($\chi^2 = 2.16$, $P > 0.9$, $df = 13$).

Different regressions were devised to estimate biomass for the larger species (Table 1). The values of r and b were similar and significant at $P = 0.01$ in all cases. Moreover, the power function here yielded a better prediction of biomass than either exponential or linear regression (lower S_{yx}). Since large-sized specimens showed the greatest differences between estimated and actual biomass values, removing species composed of such individuals (*Scarabaeus sacer* L.) from the sample greatly improved predictability based on linear regression. Generally, for small dry insects species the linear relationship may be best, but in the case of heavier species a power function provides better predicted values (see Fig. 7 in Griffiths, 1973).

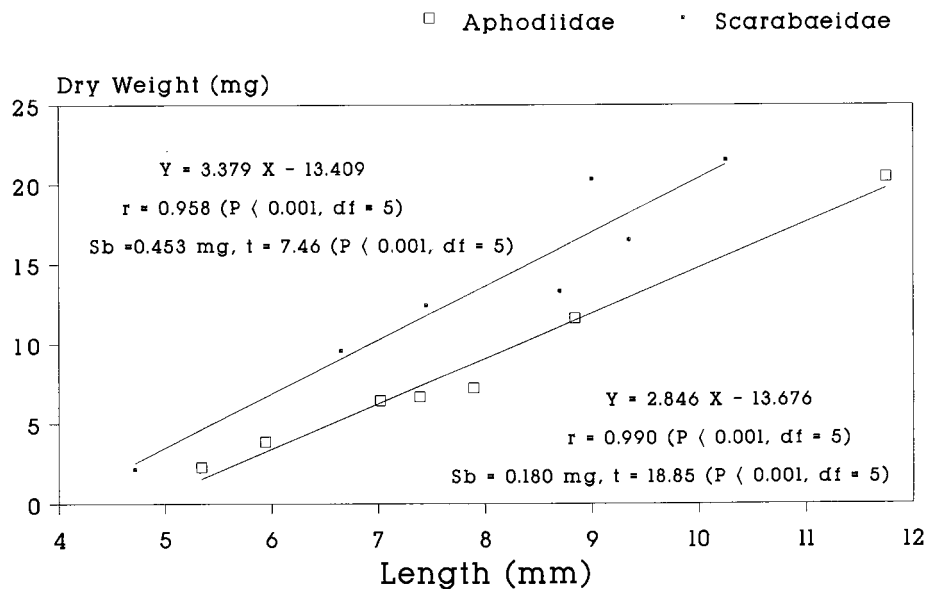


Fig. 2. Length-weight linear regression for the smaller species.

TABLE 1. Results of different length-weight regressions for all species (A, $n = 30$), the larger species (B, $n = 16$), and the larger species without *Scarabaeus sacer* L. (C, $n = 15$).

		a	b	r	S_{yx}	Sb	t	df
A	total power regression	-1.964	3.316	0.989	60.04	0.092	36.225	28
B	linear regression	-466.781	36.246	0.935	59.07	3.670	9.875	14
	power regression	-1.072	2.647	0.953	40.51	0.225	11.742	14
	exponential regression	2.87	0.127	0.941	40.69	0.012	10.436	14
C	linear regression	-293.288	26.96	0.937	34.88	2.803	9.618	13
	power regression	-0.954	2.554	0.932	36.73	0.275	9.281	13

The logarithmic transformations used in power regression diminish the contribution of larger specimens more than that of the smaller ones (Tausch & Tueller, 1988). If the range of values is small, because the species have a similar morphometric plain (i.e. groups with similar body-shape and small range of lengths), linear regression can produce more accurate biomass predictions. We would thus avoid the problems that might be caused by the log transformation or by complex mathematical methods (Sprugel, 1983). Nevertheless, if the group to be studied varies notably in shape, or if it is comprised of large and heavy species, the power relationship will probably give the best results.

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