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Frog morphometrics: a cautionary tale

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Scant attention has been paid to measurement error in frog morphometric studies. We study both interobserver effects of measurement on the same specimens of *Vanzolinius discodactylus* (Anura, Leptodactylidae) and intraobserver effect of repeated measurements on a single *V. discodactylus* specimen. Interobserver measurements differ statistically and result in different biological interpretations in some cases. Evidence is provided that log transformation of raw data is often unnecessary. Allometric transformation of measurement variables to remove size effect requires parallel regression slopes of variable against size. This requirement is not met with the *V. discodactylus* data, nor is it likely to be met when several variables are used in a morphometric study. We recommend: assume measurement differences between sexes in frogs and analyze data separately by sex; consider and select the most appropriate statistical model options for data analyses; avoid pseudoprecise measurements; do not rush to logarithmic transformation; remeasure at least one individual frog 20 times to provide an assessment of measurement error in data interpretation; be conservative in drawing biological inferences from morphometric analyses, basing interpretations and conclusions only on very robust effect size estimates and differences.

INTRODUCTION

Frogs are relatively soft-bodied organisms and their preservation requires considerable care. Limbs and body must be correctly positioned to achieve standardized preparation. Unfortunately, different preservatives and different individual techniques result in very different museum preparations for the same species (fig. 1). Therefore, precise, comparable measurements of preserved frogs are difficult. For example, one of the standard measurements taken on frogs, snout-vent length (SVL), is somewhat problematic in larger preserved frogs, because the sacral-urostyle portion of the body usually is fixed at an obtuse angle to the vertebral column. How much one "straightens out" the preserved animal has an effect on the

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