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Comment on "Habitat Split and the Global Decline of Amphibians"

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Becker *et al*. (Reports, 14 December 2007, p. 1775) reported that forest amphibians with terrestrial development are less susceptible to the effects of habitat degradation than those with aquatic larvae. However, analysis with more appropriate statistical methods suggests there is no evidence for a difference between aquatic-reproducing and terrestrial-reproducing species.

Amphibians are important indicators of environmental degradation and climate change (*1*). Becker *et al*. (*2*) hypothesized that human-induced splitting of habitats used by larval and adult life-history stages should affect species with aquatic larvae differently than those with terrestrial development. Based on a study of Brazilian leaf-litter frog communities at 12 sites, they concluded that (i) a new measure of habitat quality (habitat split, the percentage of total stream length that does not overlap with covered forest) better predicts species richness than some other indicators, and (ii) habitat split differentially affects species with aquatic versus terrestrial modes of development; specifically, species richness of terrestrial-reproducing amphibians (in which eggs develop terrestrially without free water) is not affected by habitat degradation. Although the first conclusion of Becker *et al.* is not at issue, the second conclusion merits a closer look because it has implications for managing amphibian habitats in regions of endangered biodiversity.

Becker *et al*. (*2*) argued that terrestrial-reproducing species should show no effect of habitat degradation because they reproduce even if water bodies have been isolated from the species' forest habitats. The hypothesis predicts (as a null) that environmental quality (habitat split) has no effect on the proportions of aquatic- and terrestrial-reproducing species over sites. Becker *et al*. concluded that a differential effect was present, based on a significant linear regression of habitat split on number of aquatic-reproducing species compared with a nonsignificant regression on number of terrestrial-reproducing species. However, their comparison of two regressions (reproduced in Fig. 1B) does not adequately test the hypothesis. That one regression is significant and the other is not does not test whether the two regressions are significantly different from each other. In fact, the slopes of the two regressions (Fig. 1B) are not significantly different by analysis of covariance (*3*) (Student's *t* test = 1.64; df = 20; *P* = 0.12).

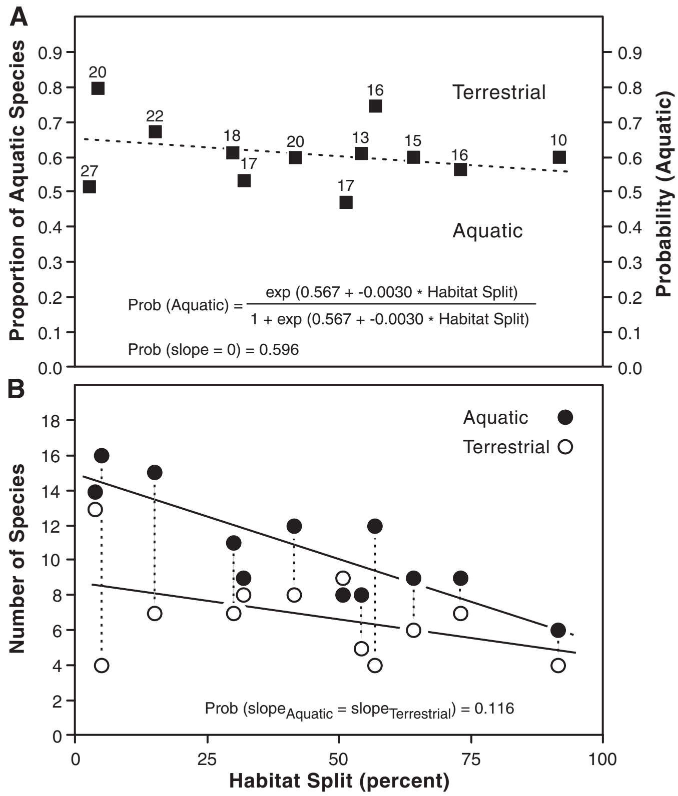

Fig. 1. (**A**) The left *y* axis shows the proportions of aquatic-reproducing species for 12 sites (black squares with total number of species) against habitat split. The right *y* axis shows the probability (from the dotted logistic regression line) of any sampled species being aquatic for a given value of habitat split. The regression slope is not different than 0 ($P = 0.596$). Although the logistic regression line appears linear over the range shown, it is actually a curvilinear function. (**B**) Plot of data from Becker *et al*. (*2*). The slopes of the regression lines for aquatic and terrestrial species are not significantly different (analysis of covariance, $P = 0.116$).

Moreover, comparison of these two regressions is inappropriate because the dependent or outcome variable (numbers of species per site in each reproductive category) does not vary independently between the regressions; the number of "aquatic" or "terrestrial" species is simply a proportion of the total number of species. The more appropriate outcome variable is binary; a given species is either aquatic- or terrestrial-reproducing (regardless of site). Because the outcome has a binomial distribution, it is properly analyzed using logistic regression (*3*, *4*). The independent continuous variable, habitat split, predicts the proportion of species with each reproductive mode at each site.

Inspection of the Becker *et al*. data [supporting online material for (*2*)] suggests no obvious change in proportions over increasing values of habitat split (Fig. 1A). Logistic regression (Fig. 1A) finds no significant effect of habitat split on proportions of aquatic/terrestrial-developing species (regression coefficient $b = -0.003$; 95% CI: -0.0140 to 0.0080; $\chi^2 = 0.28$; $P = 0.596$). Other measures of habitat quality show similar nonsignificant effects (habitat fragmentation: $b = -0.80$, chi-square = 0.04, $P = 0.846$; habitat loss: $b = -0.0006$, $\chi^2 = 0.02$, $P = 0.896$).

An alternative approach is an ordered contingency table (*5*) in which a numerical value (habitat split) is allocated to the categories (sampling sites) and linear regression techniques are used. Although the intermediate computations differ, the result is identical to logistic regression. The total χ^2 is 7.498, and the χ^2 due to the regression is only 0.282, with $P = 0.596$ (df = 1).

Thus, the Becker *et al*. data do not provide support for the hypothesis that terrestrial-reproducing frogs respond differently to habitat degradation. In fact, the lack of detectable trend in the proportions of aquatic/terrestrial-developing species over 12 sites reinforces the first conclusion of Becker *et al*. (*2*)—a strong, significant effect of habitat split on overall species richness—but that effect obtains regardless of reproductive mode. Terrestrial reproduction, an evolutionary adaptation that freed species from the requirement for aquatic breeding habitat (*6*), nevertheless does not insulate these species from the effects of habitat degradation. This finding emphasizes the need for protection of riparian zones joining both aquatic and terrestrial habitats, especially in biodiverse regions such as southeast Brazil.

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References and Notes

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