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LOOKING FOR DISCONTINUITIES AND BREAKING POINTS IN THE RELATIONSHIPS BETWEEN SPECIES AND HABITAT

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Temporal trends, and the relationship between species distribution and habitat**,** are usually analysed via regression or generalized additive models (GAMs). Standard regression techniques and GAMs allow to test for linear or curvilinear relationships. However, not all the relationships are expected to be linear or curvilinear. For instance, theoretical models suggest the existence of thresholds in the response of species to environmental modifications. For example, species can undergo to decline when the percentage of suitable habitat falls under a given threshold value. Above this threshold, the species is apparently not affected by environmental alteration; below this threshold, species can abruptly disappear (Fahrig, 2002, Ecol. Appl. 12:346-353). Similarly, events occurring during temporal series can cause abrupt changes in the response variables. We applied Strucchange (Zeileis et al. 2003, Comput. Stat. Data An. 44:109-123), a recent a statistical tool developed for other disciplines, to the study of temporal trends and species habitat relationship in several species of amphibians and reptiles. We also compared the results of Strucchange with those of other techniques used to detect discontinuities. Strucchange detected a significant threshold pattern in the relationship between occurrence of *Triturus helveticus* in 371 ponds and the amount of forest cover (SupF = 29.603, P < 0.0001: Fig. 1), suggesting that above a given amount, increases of habitat availability do not increase species frequency. By contrast, in 77 streams monitored for *Salamandra salamandra*, Strucchange did not detect any threshold value (SupF = 8.32, P = 0.11, Fig. 1), and a nonlinear increase of the occurrence of *S. salamandra* in landscape having more suitable terrestrial habitat was the best model (F = 7.149, d.f. = 2.148, P = 0.009, delta AIC = 0.97, Fig. 1).

Strucchange can detect breaking points also in temporal series. A model allowing both abrupt thresholds and nonlinear variations was the better description of the temporal variation of nesting activity of *Eretmocheys imbricata* in a beach of Qatar; this model outperformed both classical linear models (delta AIC = 32) and GAMs (delta AIC = 12).

Strucchange always detected a significant threshold if the threshold was detected by other parametric and nonparametric tools, such as piecewise regression, AIC comparison among models and recoursive tree partitioning, suggesting that Strucchange is one of the most powerful tools available for this scope. Statistical models including discontinuities can outperform the linear and nonlinear ones, this suggest that the possibility of breaking points should be considered for a better understanding of processes influencing amphibians and reptiles; tools such as Strucchange allow for a rigorous testing and positioning of threshold values. Its availability as free software within the R environment (www.r-project.org) encourages a wider use of this method.

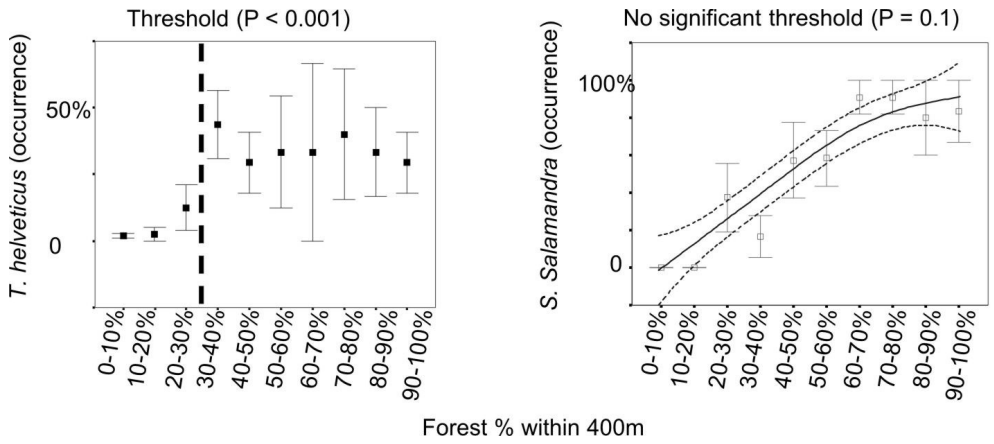

Fig. 1. Analysis of threshold in two species of urodele. For *T. helveticus*, the broken line is the position of the threshold; for *S. salamandra* it is showed the fitted GAM with 95% C.I.

Key words: *statistical methods, ecological threshold, habitat amount, temporal series.*

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Riassunti

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