The roles of error structure specification, parameter minimization and uncertainty estimation on model assessment: an information-theoretic approach with two endangered vertebrate species

Pablo Almaraz[1] and Juan A. Amat[2] .

Stochasticity and uncertainty estimation methods play a key role in current population models for wildlife conservation [1]; indeed, stochastic components provide robust connections between models and reality [1,2]. Misspecifications of error structure or parameter minimization methods may severely bias model assessments, population forecasting, and estimates of extinction risk. In recent years, several modeling efforts have included environmental covariates in model construction in order to reduce uncertainty on final estimates [review in 2].

From an information-theoretic perspective, here we use data from the Spanish population of the globally threatened White-headed duck (*Oxyura leucocephala*), and from the endangered San Joaquin kit fox (*Vulpes macrotis mutica*) population in California, U.S.A. [2] in order to investigate the effects of different parameter estimation methods, error structure specifications, and uncertainty estimation on final population dynamics model assessment. We use the well-known Ricker and Gompertz models with environmental covariates included, and specify three different link functions for the growth rate in a generalized linear design: log, power and identity [3]; then, we use four different parameter estimation methods (maximum likelihood, ordinary least squares, generalized least squares, and asymptotically distribution-free); and finally, we estimate confidence intervals for parameters based on normal distribution theory, and from a set of bootstrapped values using the bias-corrected bootstrap confidence limits [4].

The link function and dynamic dimension minimizing the Bayesian Information Criterion (BIC) suggested the functional form and complexity of each model, which always included environmental covariates. We found that point parameter estimates derived from different estimation methods were roughly similar within both species; nevertheless, the BIC tended to select models with least-squares estimated parameters in both species. On the other hand, confidence intervals varied greatly between different estimation methods. Indeed, bootstrap estimated uncertainty was in general larger for all parameters than original values, whatever the estimation method used. This result point to the need of placing more care during the selection of the uncertainty estimation method, since this may have essential implications for model assessment and subsequent population viability analysis.

[1]Departamento de Biología Animal y Ecología, Facultad de Ciencias, E-18071, Universidad de Granada, Granada, Spain (e-mail: almaraz@fedro.ugr.es).
[2]Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas, Apdo. 1056, E-41080, Sevilla, Spain (e-mail: aguilar@cica.es).

References

[1] Lande, R., Engen, S. and Sther, B.-E. Stochastic population dynamics models in ecology and conservation: an introduction. Oxford University Press, Oxford, 2003.

[2] Dennis, B. and Otten, M. R. M. Joint effects of density-dependence and rainfall on abundance of San Joaquin Kit fox. J. Wildl. Manage., 64, 388-400, 2000.

[3] McCullagh, P. and Nelder, J. A. Generalized linear models. Chapman & Hall, New York, 1983.

[4] Efron, B. and Tibshirani, R. J. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science, 1, 54-77, 1986.