Ecological Archives E089-145-A1

Olivier Marquis, Manuel Massot, and Jean François Le Galliard. 2008. Intergenerational effects of climate generate cohort variation in lizard reproductive performance. *Ecology* 89:2575–2583.

Appendix A. Analysis of cohort variation in juvenile survival.

Data set

The data set consisted of 2044 recapture histories of offspring born from known-age mothers and recaptured 1 month, 10 months and 22 months after hatching (see *Methods* for more details). The recapture histories encompassed 2922 observations and 13 cohorts (1988–2000). Since there was some variability in age at recapture for the first session (mean = 36.4 days ± 15.25 s.d., range = 4–70 days), we discarded recaptures done less than three weeks after hatching to enable proper assessment of early juvenile survival (ca. 25 % of recaptures, mean age of recaptures = 42 days). Cohorts were coded with 13 dummy variables and the data set also included one individual covariate (size at birth) and four climatic covariates (rainfall and temperature during grandmother gestation, rainfall during mother gestation and rainfall during the first month of life). Grandmaternal and maternal meteorological covariates were included since these climate conditions during gestation were found to influence offspring traits (see *Results* section). Furthermore, the effect of temperature during gestation was discarded and that of rainfall during early life was included on the basis of an analysis of annual variation in juvenile survival (Le Galliard et al., *unpublished data*). Covariates were standardised prior to analysis. To get estimates of monthly survival probabilities, we set time-intervals between capture sessions as 1 month, 9 months and 12 months, respectively.

GOF tests

We based our goodness-of-fit (GOF) tests on the Cormack-Jolly-Seber (CJS) model without individual covariates. The CJS model is a closed population model enabling the joint estimation of survival and capture probabilities from recaptures data set (Choquet et al. 2005). This model (denoted $\Phi_{a*cohort}\ p_{a*cohort}$) made the sole assumption that survival and capture probabilities varied with age[1] and among cohorts. We first run the CJS model in M-SURGE 1.8 to diagnose convergence and detect redundant parameters (Choquet et al. 2005). The model had a rank of 65 parameters according to the numerical approach implemented in M-SURGE and tests of deviance profiles for parameters located at the boundaries (Choquet et al. 2005). The CJS model converged satisfactorily and fitted well the data (quadratic $\chi2 = 15.49$, df = 13, $P = 0.27$). The test 2.CT implemented in U-CARE 2.2 (Choquet et al. 2005) showed no effect of previous capture on the probability of recapture conditional on survival. The parametric bootstrap GOF tests of program MARK (Anderson 1978) further indicated no evidence of overdispersion (1,000 bootstrap simulation, GOF test: $P = 0.16$). Thus, the CJS model was used as a starting point to select a parsimonious model with the lowest AICc (Burhnam 1992, Choquet et al. 2005).

Model selection and hypotheses tests

Model selection and parameter estimation was conducted with the software MARK (White and Burnham 1999) following the methodology of (Choquet et al. 2005). The CJS model was first simplified to get a better model describing capture probabilities. The most parsimonious model was by far the age-dependent model ($\Phi_{a*cohort}\ p_a$, see Table A1a). Capture probabilities were significantly lower at the age of one month (0.29 [0.25, 0.34] 95% CI) than at the age of ten months (0.40 [0.30, 0.49]). This model was then simplified to select a more parsimonious model describing survival probabilities, which indicated substantial age-dependent cohort variation in juvenile survival (Table S1b). A check of the survival estimates showed that early juvenile survival (0.44 ± 0.07 SE) was substantially lower and varied more than late juvenile survival (0.92 ± 0.02 SE), which is in accordance with the low winter mortality observed in previous studies (Van Damme et al. 1991). Age-dependency in cohort variation was caused by an increase in early juvenile survival in the last cohorts (1998–2000) that was not paralleled by a similar increase in late juvenile survival. An analysis of deviance (ANODEV) was used to partition cohort-level variation in juvenile survival between variation explained by grandmaternal climatic covariates (rainfall and temperature during grandmother's gestation) and unexplained variation (Skalski et al. 1993). The results of this ANODEV showed that the contribution of grandmaternal climatic conditions was too small to be significant (Table A2). However, there were significant effects of rainfall during gestation, rainfall during the first month of life and body size at hatching on juvenile survival (Table A1c). The two most parsimonious models indicated positive effects of body size on early and late juvenile survival, as well as positive effects of rainfall during gestation and during the summer on early juvenile survival. Stronger effects were that of body size at hatching on early juvenile survival (standardized selection gradient = 0.18 [0.02, 0.35] 95% CI) and that of rainfall during the summer on early juvenile survival (logit slope = 0.27 [0.03, 0.51]).

LITERATURE CITED

Anderson, M. 1978. Natural selection of offspring numbers: some possible intergeneration effects. American Naturalist 112:762–766.

Burhnam, K. P. 1992. A theory for combined analysis of ring recovery and recapture data. Pages 199–213 *in* J. D. Lebreton and N. North, editors. Marked individuals in the study of bird populations. Birkhauser Verlag, Basel.

Choquet, R., A. M. Reboulet, R. Pradel, O. Gimenez, and J. D. Lebreton. 2005. M-SURGE 1.8 User's Manual. CEFE, Montpellier, France.

Skalski, J. R., A. Hoffmann, and S. G. Smith. 1993. Testing the significance of individual- and cohort-level covariates in animal survival studies. Pages 9–28 *in* J. D. Lebreton and P. M. North, editors. Marked individuals in the study of bird populations. Birkäuser Verlag, Basel.

Van Damme, R., D. Bauwens, and R. F. Verheyen. 1991. The Thermal Dependence of Feeding Behaviour, Food Consumption and Gut-Passage Time in the Lizard Lacerta vivipara Jacquin. Functional Ecology 5:507–517.

White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46:120–138.

TABLE A1. Mark–recapture models for age-dependence and cohort variation in capture probabilities (a) and survival probabilities (b and c). The most parsimonious models according to the AICc are indicated in bold using ΔAICc<2 as a threshold criterion.

Model name	**AICc score**	**ΔAICc**	**AICc weight**	**Model likelihood**	**Rank**	**Deviance**

(a) Selection of a model describing recapture probabilities						
$\Phi_{a*cohort}\ p_{a*cohort}$	3186.19	18.35	0.0001	0.0001	65	3052.59
$\Phi_{a*cohort}\ p_{a+cohort}$	3177.34	9.51	0.0084	0.0086	53	3068.95
$\Phi_{a*cohort}\ p_a$	**3167.83**	**0**	**0.97**	**1**	**41**	**3084.40**
$\Phi_{a*cohort}\ p_{cohort}$	3188.28	20.44	0.00004	0	52	3081.98
$\Phi_{a*cohort}\ p.$	3175.82	7.98	0.018	0.0184	40	3094.46
(b) Selection of a model describing survival probabilities						
$\Phi_{a*cohort}\ p_a$	**3167.83**	**0**	**1**	**1**	**41**	**3084.40**
$\Phi_{a+cohort}\ p_a$	3208.65	40.82	0	0	17	3174.40
$\Phi_a\ p_a$	3265.36	97.53	0	0	5	3255.34
$\Phi_{cohort}\ p_a$	3291.50	123.67	0	0	16	3259.28
$\Phi.\ p_a$	3303.29	135.45	0	0	4	3295.27
(c) Selection of a covariate model describing survival probabilities						
$\Phi_{a*cohort}\ p_a$	3167.83	7.35	0.0109	0.0253	41	3084.40
$\Phi_{a*cohort+size}\ p_a$	3164.85	4.37	0.0483	0.1124	43	3077.28
$\Phi_{a*cohort+a1*size}\ p_a$	3165.32	4.84	0.0382	0.089	42	3079.82
$\Phi_{a*cohort+size+rain}\ p_a$	3162.62	2.14	0.1472	0.343	47	3066.74
$\Phi_{a*cohort+size+a1*rain}\ p_a$	**3160.48**	**0**	**0.4293**	**1**	**45**	**3068.76**
$\Phi_{a*cohort+a1*(size+rain)}\ p_a$	**3161.03**	**0.55**	**0.3261**	**0.7597**	**44**	**3071.38**

Definitions: p = capture probability, Φ = survival probability, a = age, a1 = early juvenile stage, size = body size at hatching, rain = rainfall during gestation and early juvenile stage.

Table A2. Sequential analysis of deviance showing the proportion of inter-cohort variation in survival probabilities explained by cohort-specific climate covariates. Cohort-specific climate covariates (grandmaternal rainfall and temperature during gestation) had no detectable effect on juvenile survival.

Models	**Terms**	**Deviance**	**Rank**	**F ndf,ddf**	**p value**
$\Phi_a\ p_a$	Constant	3255.34	5		
$\Phi_{a*grain}\ p_a$	Grandmaternal rainfall	3245.91	8	$0.64_{3,33}$	0.59
$\Phi_{a*(grain+gtemp)}\ p_a$	Grandmaternal temperature	3232.78	11	$1.30_{3,30}$	0.29
$\Phi_{a*cohort}\ p_a$	Grand total	3084.40	41		

Definitions: p = capture probability, Φ = survival probability, a = age, grain = rainfall during grandmother gestation, gtemp = temperature during grandmother gestation.

1 Since cohorts were coded with dummy variables, time-dependence means the same as age-dependence here.

[Back to E089-145]