Eva Conquet, Arpat Ozgul, Daniel T. Blumstein, Kenneth B. Armitage, Madan K. Oli, Julien G. A. Martin, Tim H. Clutton-Brock, Maria Paniw. 2021. Demographic consequences of changes in environmental periodicity. *Ecology.*

Data and R scripts to reproduce the analysis of the effect of changes in environmental periodicity on the marmot (*Marmota flaviventer*) population.

Author(s)

Eva Conquet
Department of Evolutionary Biology and Environmental Studies, University of Zurich
Winterthurerstrasse 190, Zurich 8057, Switzerland
eva.conquet@uzh.ch

Arpat Ozgul
Department of Evolutionary Biology and Environmental Studies, University of Zurich
Winterthurerstrasse 190, Zurich 8057, Switzerland
arpat.ozgul@ieu.uzh.ch

Daniel T. Blumstein
Department of Ecology and Evolutionary Biology, University of California Los Angeles
Los Angeles, CA 90095, USA
The Rocky Mountain Biological Laboratory
Crested Butte, CO 81224, USA
marmots@ucla.edu

Kenneth B. Armitage
Department of Ecology and Evolutionary Biology, The University of Kansas
Lawrence, KS 66045-7534, USA
marmots@ku.edu

Madan K. Oli
Department of Wildlife Ecology and Conservation, University of Florida
Gainesville, FL 32611, USA
olim@ufl.edu

Julien G. A. Martin
Department of Biology, University of Ottawa
Ottawa K1N 9A7, Canada
School of Biological Sciences, University of Aberdeen
Aberdeen AB24 2TZ, UK

julien.martin@uottawa.ca

Tim H. Clutton-Brock
Department of Zoology, University of Cambridge
Downing Street, Cambridge CB2 3EJ, UK
Kalahari Research Trust
Kuruman River Reserve, Northern Cape, South Africa
Mammal Research Institute, University of Pretoria
Pretoria, South Africa
thcb@cam.ac.uk

Maria Paniw
Department of Evolutionary Biology and Environmental Studies, University of Zurich
Zurich 8057, Switzerland
Department of Conservation and Global Change, Doñana Biological Station (EBD-CSIC)
Seville 41092, Spain
m.paniw@gmail.com

File list

`MarmotsData.csv`
`01_Marmots_VitalRatesEstimation.R`
`02_Marmots_MPMs.R`
`03_Marmots_Simulations.R`
`04_Marmots_Results.R`
`05_Marmots_Elasticities_Mean_SD.R`

Description

`MarmotsData.csv` – This dataset contains individual capture-recapture data collected on a population of yellow-bellied marmots (*Marmota flaviventer*) between 1976 and 2016 at 2900 masl in the upper East River Valley near Gothic, Colorado, United States. For each individual at each capture, the data contains information on the season (summer or winter) and year of capture, the life-history stage (stage_surv; J = juvenile, Y = yearling, NRA = non-reproductive adult, and RA = reproductive adult), whether the individual survived (surv; 1 if it survived, 0 if not), whether it became reproductive (transRA; 1 if it became reproductive, 0 if not), and the number of pups the individual had (recruits). This dataset is used to estimate vital rates in the marmot population and assess the effect of changes in vital-rate seasonality on the marmot population dynamics.

`01_Marmots_VitalRatesEstimation.R` – This script uses the individual capture-recapture data on the marmot population to estimate survival, transition, and recruitment rates. We estimated vital rates using binomial (for survival and transition rates) and Poisson generalized linear mixed models (GLMMs; for the recruitment rate). We

included season as a fixed effect and year as a random effect either on the intercept only or both on the intercept and the difference between seasons. We selected the best random effect by looking at the part of the variance explained by a year random effect compared to no random effect, using the *r.squaredGLMM* function of the *MuMIn* R package. We selected the best fixed effect using the AICc. We checked for over- and under-dispersion in the recruitment model and fitted a quasi-Poisson model to account for it. At the end of the script, vital rates are stored in a data frame and all models are saved as `.RData` objects.

`02_Marmots_MPMs.R` – This script provides functions to build seasonal matrix population models (MPMs) for the marmot population, using vital rates estimated in `01_Marmots_VitalRatesEstimation.R`. The *marmots.buildmat.summer* function builds MPMs using summer vital rates, while the *marmots.buildmat.winter* function does the same for winter, taking year as an argument.

`03_Marmots_Simulations.R` – This script provides the *stoch.sim.marmots* function to perform simulations under a control scenario (no changes in vital-rate periodicity), and scenarios of high (higher vital-rate seasonality) and low seasonality (lower vital-rate seasonality) in yearling, non-reproductive adult, and reproductive adult survival. The function takes the number of simulations (nsimul; default is 500), the number of years in each simulation (nyears; default is 100), the initial population vector (n0), the vital rate model for which to perturb seasonality (vr.model), the seasonal threshold (seas.threshold; default is 0.5, meaning half of the years for a given vital rate will be considered highly seasonal and the other half little seasonal), and the seasonality scenario (seasonality; default is “control”, takes also “high” and “low”). The function returns a list of annual growth rates for each simulation and a vector containing a 1 if the simulation led to population quasi-extinction. The rest of the code performs all the simulations used in the manuscript and saves the results as a `.RData` object.

`04_Marmots_Results.R` – This script processes the results of the vital-rate seasonality perturbation simulations for the marmot population. It computes and plots the mean stochastic log lambda, variance across 100 log lambda, and quasi-extinction probability in each scenario across 500 simulations. The results are saved as a `.csv` file.

`05_Marmots_Elasticities_Mean_SD.R` – This script computes and plots the elasticities of the population growth rate to changes in the mean and standard deviation of each vital rate in each season. In addition, for each vital-rate category (survival, transition, and reproduction), the script computes and plots the relative effect of variability. This metric enables to evaluate the proportion of the stochastic elasticity E^S attributed to changes in the variability of a given vital rate category. The results are stored as `.csv` files.