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 meerkat (*Suricata suricatta*) 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

`MeerkatsData.csv`
`01_Meerkats_VitalRatesEstimation.R`
`02_Meerkats_MPMs.R`
`03_Meerkats_Simulations.R`
`04_Meerkats_Results.R`
`05_Meerkats_Elasticities_Mean_SD.R`

Description

`MeerkatsData.csv` – This dataset contains individual capture-recapture data collected on a population of meerkats (*Suricata suricatta*) between 1997 and 2016 in the Kuruman River Reserve, South Africa. For each individual at each capture, the data contains information on the season (dry or rain) and year of capture. The year for captures at the beginning of the wet season in October corresponds to the year of capture + 1, to have a combination of a wet and dry season in each year. In addition, the data contains information on the life-history stage (stage; J = juvenile, S = subadult, H = helper, and D = dominant), whether the individual survived (surv; 1 if it survived, 0 if not), whether it became dominant (transition; 1 if it became dominant, 0 if not), whether it emigrated (emig; 1 if it emigrated from its groups, 0 if not), and the number of pups the individual had (pups). The dataset also contains information on population home range (home.range; in km^2), and on population density (density; in number of individuals/km^2) and its squared value (density2). This dataset is used to estimate vital rates in the meerkat population and assess the effect of changes in vital-rate seasonality on the meerkat population dynamics.

`01_Meerkats_VitalRatesEstimation.R` – This script uses the individual capture-recapture data on the meerkat population to estimate survival, transition, emigration, and recruitment rates. We estimated vital rates using binomial (for survival, transition, and emigration rates) and Poisson generalized linear mixed models (GLMMs; for the recruitment rate). We included season, density, and squared density as fixed effects 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 on the intercept only compared to that on the intercept and the difference between seasons and 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 models 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_Meerkats_MPMs.R` – This script provides the *meerkats.buildmat* function to build seasonal matrix population models (MPMs) for the meerkat population, using vital rates estimated in `01_Meerkats_VitalRatesEstimation.R`. The function takes the year, season, and density as arguments and returns the corresponding MPM.

`03_Meerkats_Simulations.R` – This script provides the *stoch.sim.meerkats* 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 subadult, helper, and dominant survival, helper emigration, transition from helper to dominant, and helper and dominant recruitment. The function takes the number of simulations (nsimul; default is 500), the number of years in each simulation (nyears; default is 100), the number of seasons (nseas, default is 2), the initial population vector (n0), the initial population density (dens0), 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), the density scenario (density; TRUE if density dependence should be taken into account, FALSE if simulations should be performed at average population density), 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, a vector containing a 1 if the simulation led to population quasi-extinction, and a list of yearly population densities for each simulation. The rest of the code performs all the simulations used in the manuscript and saves the results as a `.RData` object.

`04_Meerkats_Results.R` – This script processes the results of the vital-rate seasonality perturbation simulations for the meerkat 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.

`011_Meerkats_VitalRatesEstimation_DensityOnly.R` – This script fits models without the season fixed or random effect from the best model selected for each vital rate in `01_Meerkats_VitalRatesEstimation.R`. These models thus estimate

mean annual vital rates instead of seasonal ones. These rates are then stored in a data frame and the new models are saved as .RData objects.

021_Meerkats_MPMs_DensityOnly.R – This script provides the *meerkats.buildmat* function to build matrix population models (MPMs) for the meerkat population, using vital rates estimated in 012_Meerkats_VitalRatesEstimation_DensityOnly.R. The function takes the year and density as arguments and returns the corresponding MPM.

031_Meerkats_Simulations_DensityOnly.R – This script provides the *stoch.sim.meerkats* 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 subadult, helper, and dominant survival, helper emigration, transition from helper to dominant, and helper and dominant recruitment. The function projects the population in seasonal time steps with density feedbacks as in 03_Meerkats_Simulations.R but assumes that vital rates do not vary between seasons, using models without seasons fitted in 011_Meerkats_VitalRatesEstimation_DensityOnly.R to predict vital rates. The years of higher or lower seasonality in the various vital rates are taken from the models fitted in 01_Meerkats_VitalRatesEstimation.R. The function returns a list of annual growth rates for each simulation, a vector containing a 1 if the simulation led to population quasi-extinction, and a list of yearly population densities for each simulation. The rest of the code performs all the simulations used in Appendix S7 and saves the results as a .RData object.

041_Meerkats_Results_DensityOnly.R – This script processes the results of the vital-rate perturbation simulations for the meerkat 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. This script also contains the linear model to explore the relationship between population density and season and the violin plot showing the variation in density in both seasons, both of which are available in Appendix S7: Table S3 and Fig. S4.

05_Meerkats_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, emigration, 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.