### Eva Conquet, Maria Paniw, Natalia Borrego, Chloé R. Nater, Craig Packer, Arpat Ozgul. 2024. Seasonality mediates vital-rate responses to socially- and spatially-explicit density in an African lion population. *Journal.*

### Data and R scripts to reproduce the analysis of the effect of density at the group and home-range levels on reproduction probability and recruitment (i.e. number of cubs surviving for at least 1 year) of female African lions *Panthera leo* in the Serengeti.

### Author(s)

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

Maria Paniw

Department of Evolutionary Biology and Environmental Studies, University of Zurich

Department of Conservation and Global Change, Doñana Biological Station (EBD-CSIC)

Natalia Borrego

Department of Ecology, Evolution, and Behavior, University of Minnesota

Department for the Ecology of Animal Societies, Max Planck Institute of Animal Behavior

Department of Biology, University of Konstanz

Chloé R. Nater

The Norwegian Institute for Nature Research (NINA)

Craig Packer

Department of Ecology, Evolution, and Behavior, University of Minnesota

Arpat Ozgul   
Department of Evolutionary Biology and Environmental Studies, University of Zurich

### File list

01\_LionsFemalesDemograhicData.csv

021\_Covariate\_PopulationSize.csv

022\_Covariate\_SeasonalPrecipitation.csv

01\_GLMMs.R

02\_ModelProcessing.R

03\_SimulatingDatasets.R

04\_PosteriorPredictiveChecks.R

05\_EpsilonRainfallPopulationSize\_Correlations.R

**Description**

01\_ LionsFemalesDemograhicData.csv – This dataset contains the seasonal demographic data of female from a population of African lions *Panthera leo* monitored between 1984 and 2014 in the Serengeti National Park, Tanzania. For each individual captured in a given capture occasion, the data contains information on the season in character (wet or dry) and number (season.nb; 1 = wet and 2 = dry), the year (with 1 = 1985 in year.nb) ), the habitat in character (grassland or woodland) and in numbers (habitat.code; 1 = grassland, 2 = woodland), the age at capture, in years (age.at.capture), the needed covariates (number of adult females in the pride, number of nomadic coalitions in the home range), the survival (0 = survived to the next timestep, 1 = did not survive), whether the lioness reproduced in that season (reproduction = 0 if she did not, 1 if she did), and the number of cubs assigned to the lioness and who survived at least until their first birthday (cubs).

021\_Covariate\_PopulationSize.csv – This dataset contains a 1-column table with information on the number of individuals in the population at each capture occasion. Population size includes all individuals, including those removed from the capture histories (e.g., lions that could not be clearly identified or nomadic females).

022\_Covariate\_SeasonalPrecipitation.csv – This dataset contains a 1-column table with information on the cumulative amount of rainfall (in mm) in each season throughout the study.

01\_GLMMs.R – This script uses the female lion demographic data 01\_ LionsFemalesDemograhicData.csv including the density, age, and habitat covariates, to fit two GLMMs and estimate reproduction probability and recruitment to 1 year old. The script contains code to setup the data, constants, initial values, and NIMBLE code to model these two reproductive rates as functions of various season-specific density measures at the group and home-range level, age, and habitat. We also use a year random effect in all models. We monitor parameters such as beta coefficients, sigmas, and epsilons. We store the model output as an .RData file.

02\_ModelProcessing.R – This script uses the MCMC output to process and plot the results of the multistate model: The season-specific prior-posterior overlap, the size effects, and the predicted vital rates (median and 90% credible intervals) as a function of a given covariate. The script also allows to plot the season-specific median and credible intervals of epsilon samples. All plots are created using the *ggplot2* R package and stored as .png or .pdf files.

03\_SimulatingDatasets.R – This script uses 500 sampled values from the GLMMs MCMC posterior samples of each parameter to simulate 10 demographic dataset with reproduction and recruitment data per sampled set of parameter values. The simulated datasets use the observed covariate values and the sampled parameters to assign a 0 or 1 to reproduction and a number of cubs to each female in each row of the original data. The resulting 5000 simulated capture histories are stored in a list as an .RData file.

04\_PosteriorPredictiveChecks.R – This script uses the original and simulated reproduction and recruitment data to calculate a set of metrics on each dataset and compare the distribution of metric values calculated on the simulated datasets to the true value calculated on the true data. This allows to pinpoint issues in the parameter estimates and thus potentially in the model structure. In this script, we also calculate the Bayesian p-values for each metric, that is, the proportion of values obtained from the simulated data that are larger than the true metric value. We then plot the distributions and p-values using the ggplot2 package and save these plots as .png files.

05\_EpsilonRainfallPopulationSize\_Correlations.R – This script uses the GLMMs season- and year-specific posterior samples of the epsilon values as well as the rainfall and population size covariates to calculate a correlation coefficient between each sampled time series of epsilons and the covariates. We then obtain a distribution of correlation coefficients that we plot against a 0.5 threshold to gain insight on whether there might be an effect of rainfall and population size on female reproduction probability and recruitment to 1 year old. We store the plots created using the ggplot2 R package as .png files.