**Evolutionary determinants of non-seasonal breeding in wild chacma baboons**

Under revision in The American Naturalist (manuscript number: 60524R2).

Dezeure J., Burtschell L., Baniel A., Carter A. J., Godelle B., Cowlishaw G. & Huchard E.

Contact: [dezeurejules@gmail.com](mailto:dezeurejules@gmail.com)

Dezeure J. built the datasets and wrote the codes presented in the Dryad repository, except the code of the script named ‘Model Appendix E’ which was created by Burtschell L.

In the Dryad repository, you will find 6 R scripts (.R files), along with 8 excel files (.csv files). This readme file will help you to understand how to run the various scripts, and the meaning of the different variables used in each csv table. For all R scripts, the packages used are listed on the first rows. All analyses performed for this paper have been conducted in R version 4.0.2 (R Core Team, 2018).

Note that given the uncertainties of the dates of births, conceptions, and cycle resumptions in our dataset (see Appendix A of the Supplementary Material), we ran loops with 1000 mixed models and extracted either mean AIC values (for model selection) or Rubin’s rule estimates and P-values (for results of the final model). The values of these 1000 randomized models may thus slightly differ when you run your own script (as by definition, these randomized dates will be different). However, according to our multiple checks, such differences will not alter the final results, in terms of which variable is significant or not, as well as in terms of the effect sizes associated with the different variables. Some parts of the code may be long to run (more than 10 hours), depending on the computer used.

**I/ Model 1 on interbirth interval (IBI)**

The only table needed to run the script ‘Model\_1’ is the one named ‘IBI\_Table.csv’. Here is a brief description of all the variables present in this table:

|  |  |
| --- | --- |
| Troop | Baboon group (J, L or M) |
| Mother | Mother identity |
| Month\_Birth | Month of birth of the infant opening the IBI (1 for January, etc) |
| Parity | Parity of the mother (‘primi’ for primiparous, ‘multi’ for multiparous) |
| Relative\_Rank | Relative rank of the mother |
| Rank | Rank, as a categorical variable, of the mother |
| DOB1 | Date of birth of the infant opening the IBI |
| Birth\_Rad | Date of birth, in radian, of the infant opening the IBI |
| Uncertainty\_Birth\_DayRad | Uncertainty, in radian, in the date of birth of the infant opening the IBI. |
| Sex1 | Sex of the infant opening the IBI (‘M’ for male, ‘F’ for female) |
| DeathFirstYear1 | Whether or not the infant opening the IBI died before weaning |
| DOB2 | Date of birth of the infant closing the IBI. |
| Borndead | Whether or not the infant closing the IBI was born dead |
| IBIDays | IBI duration (in days) |
| DeathInBw | Whether or not another infant died (or a fetus) in between the two births of the IBI |
| Nb\_Birth\_Before1 | Number of births 1 month before the focal birth in the group |
| NB\_Births\_15days\_Around | Number of births 1 month surrounding the focal birth in the group |
| Nb\_Birth\_After1 | Number of births 1 month after the focal birth in the group |
| NB\_Births\_2months\_before | Number of births 2 months before the focal birth in the group |
| Nb\_Birth\_Both1 | Number of births 2 months surrounding the focal birth in the group |
| NB\_Births\_2months\_after | Number of births 2 months after the focal birth in the group |
| NB\_Births\_4months\_before | Number of births 4 months before the focal birth in the group |
| NB\_Births\_2months\_Around | Number of births 4 months surrounding the focal birth in the group |
| NB\_Births\_4months\_after | Number of births 4 months after the focal birth in the group |
| Nb\_Birth\_Before6 | Number of births 6 months before the focal birth in the group |
| Nb\_Birth\_Both3 | Number of births 6 months surrounding the focal birth in the group |
| Nb\_Birth\_After6 | Number of births 6 months after the focal birth in the group |
| Dif\_NDVI | NDVI\_NS (mean non-seasonal NDVI variation) |
| Dif\_Rainfall | Rain\_NS (mean non-seasonal rainfall variation) |
| Age\_Year\_Mother | Age of the mother, in years |
| NB\_Adult\_Females\_V2 | Number of adult females in the group, at the birth date of the infant opening the IBI |

The R script ‘Model\_1’ should be self-explanatory. We first show from line 61 to 76 of the script how we computed the 1000 randomized birth dates. We then present from line 79 to 393 of the script the different steps of the model selection (see also Appendix C and Table S2 of the Supplementary Material). We then present from line 396 to 807 the code used to obtain the results presented in the main text (Table 2). Finally, from line 811 to the end of the script, we ran an alternative model, composed of variables in models for which ΔAIC were <2 (see Table S2 of the Supplementary material), and showed that it did not alter the significance of our results.

**II/ Model 2 on infant mortality**

The only table needed to run the script ‘Model\_2’ is the one named ‘Infant\_Mortality\_Table.csv’. Here is a brief description of all the variables in this table:

|  |  |
| --- | --- |
| Troop | Baboon group (J, L or M) |
| Month\_Birth | Month of birth (1 for January, etc.) |
| Mother | Mother identity |
| DOB | Date of birth of the infant |
| Parity | Parity of the mother (‘primi’ for primiparous, ‘multi’ for multiparous) |
| Relative\_Rank | Relative rank of the mother |
| Rank | Rank, as a categorical variable, of the mother |
| Sex | Sex of the infant (‘M’ for male, ‘F’ for female) |
| Uncertainty\_Rad | Uncertainty of the infant birth date, in radians |
| Birth\_radian | Birth date of the infant, in radians |
| Last\_Seen | The last day the infant was observed (in the case the infant died) |
| First\_Not\_Seen | The first day the infant was not observed (in the case the infant died) |
| Death\_18months | Whether (1) or not (0) the infant died before weaning (age of 550 days) |
| Date\_18months | The date at weaning (birth date + 550 days) |
| DateDeath | The estimated date of infant death |
| Age\_Death | The age of the infant when it died |
| Nb\_Birth\_Before1 | Number of births 1 month before the focal birth in the group |
| NB\_Births\_15days\_Around | Number of births 1 month surrounding the focal birth in the group |
| Nb\_Birth\_After1 | Number of births 1 month after the focal birth in the group |
| NB\_Births\_2months\_before | Number of births 2 months before the focal birth in the group |
| Nb\_Birth\_Both1 | Number of births 2 months surrounding the focal birth in the group |
| NB\_Births\_2months\_after | Number of births 2 months after the focal birth in the group |
| NB\_Births\_4months\_before | Number of births 4 months before the focal birth in the group |
| NB\_Births\_2months\_Around | Number of births 4 months surrounding the focal birth in the group |
| NB\_Births\_4months\_after | Number of births 4 months after the focal birth in the group |
| Nb\_Birth\_Before6 | Number of births 6 months before the focal birth in the group |
| Nb\_Birth\_Both3 | Number of births 6 months surrounding the focal birth in the group |
| Nb\_Birth\_After6 | Number of births 6 months after the focal birth in the group |
| Dif\_Rainfall | Rain\_NS (mean non-seasonal rainfall variation) |
| Dif\_NDVI | NDVI\_NS (mean non-seasonal NDVI variation) |
| NB\_Adult\_Females\_V2 | Number of adult females in the group, at the birth date of the infant |

The R script ‘Model\_2’ should be self-explanatory. We first show from line 39 to 51 of the script how we computed the 1000 randomized birth dates. We then present from line 53 to 362 of this script the different steps of the model selection (see also Appendix C and Table S2 of the Supplementary Material). We then present from line 365 to 656 the code used to obtain the results presented in the main text (Table 3). Finally, from line 660 to the end of the script, we ran an alternative model, composed of variables in models for which ΔAIC were <2 (see Table S2 of the Supplementary material), and showed that it did not alter the significance of our results.

**III/ Model 3 on cycle resumption probabilities**

The only table needed to run the script ‘Model\_3’ is the one named ‘Cycle\_Resumption\_Table.csv’. Here is a brief description of all the variables in this table:

|  |  |
| --- | --- |
| Year | Year |
| Troop | Group (J, L or M) |
| ID | Identity of the female |
| Month | Month of the year (1 for January, etc) |
| Month\_Rad | Month of the year, in radian |
| Parity | Parity of the female (‘nulli’ for nulliparous, ‘primi’ for primiparous, ‘multi’ for multiparous) |
| FPPO | Cycle resumption probability (1 when the cycle resumption occurred, 0 when it doesn't). See also main text |
| FPPO\_Uncertainty | Uncertainty, in days, of the cycle resumption date |
| FPPO\_Date | Cycle resumption date |
| NB\_Adult\_Females\_V2 | Number of adult females in the group in the given month |
| Number\_Conc\_Update0 | Number of conceptions occurring the same month of the focal event |
| Number\_Conc\_Update1 | Mean number of conceptions occurring over the past month before the focal event |
| Number\_Conc\_Update2 | Mean number of conceptions occurring over the past 2 months before the focal event |
| Number\_Conc\_Update4 | Mean number of conceptions occurring over the past 4 months before the focal event |
| Number\_Conc\_Update6 | Mean number of conceptions occurring over the past 6 months before the focal event |
| SynchConc1 | Mean number of conceptions occurring in the 2 months surrounding the focal event |
| SynchConc2 | Mean number of conceptions occurring in the 4 months surrounding the focal event |
| SynchConc3 | Mean number of conceptions occurring in the 6 months surrounding the focal event |
| AfterConc1 | Mean number of conceptions occurring in the month after the focal event |
| AfterConc2 | Mean number of conceptions occurring in the 2 months after the focal event |
| AfterConc4 | Mean number of conceptions occurring in the 4 months after the focal event |
| AfterConc6 | Mean number of conceptions occurring in the 6 months after the focal event |
| Relative.rank | Relative rank of the female |
| Rank | Rank, as a categorical variable, of the female |
| Dif\_Rainfall0 | Non-seasonal rainfall variation in the same month (for Dif\_RainfallX, mean non-seasonal rainfall variation over the past X months, X going from 1 to 12) |
| Dif\_NDVI0 | Non-seasonal NDVI variation in the same month (for Dif\_NDVIX, mean non-seasonal NDVI variation over the past X months, X going from 1 to 12) |
| Rainfall\_Seasonality0 | Seasonal rainfall variation in the same month (for Rainfall\_SeasonalityX, mean seasonal rainfall variation over the past X months, X going from 1 to 12) |
| NDVI\_Seasonality0 | Seasonal NDVI variation in the same month (for NDVI\_Seasonality X, mean seasonal NDVI variation over the past X months, X going from 1 to 12) |
| vec | Randomized cycle resumption probability, taking into account the uncertainty of the cycle resumption date. 1000 randomized vectors (see main text) |

The R script ‘Model\_3’ should be self-explanatory. We first show from line 15 to 65 of the script how we computed the 1000 randomized cycle resumption dates, i.e. how we obtained the 1000 vectors of the table. We then present from line 70 to 740 of the script the different steps of the model selection (see also Appendix D and Table S3 of the Supplementary Material). We then present from line 743 to 1032 the code used to obtain the results presented in the main text (Table 4). Finally, from line 1035 to the end of the script, we ran an alternative model, composed of variables in models for which ΔAIC were <2 (see Table S3 of the Supplementary material), to show that it did not alter the significance of our results.

**IV/ Model 4 on conception probabilities**

The only table needed to run the script ‘Model\_4’ is the one named ‘Conception\_Table.csv’. Here is a brief description of all the variables in this table:

|  |  |
| --- | --- |
| Year | Year |
| Troop | Group (J, L or M) |
| ID | Identity of the female |
| Month | Month of the year (1 for January, etc) |
| Month\_Rad | Month of the year, in radian |
| Parity | Parity of the female (‘nulli’ for nulliparous, ‘primi’ for primiparous, ‘multi’ for multiparous) |
| Conc | Conception probability (1 when the conception happened, 0 when the female was cycling a given month but did not conceive) |
| CONC\_Date | Conception dates |
| CONC\_Uncertainty | Uncertainty of the conception date, in days |
| NB\_Adult\_Females\_V2 | Number of adult females in the group in the given month |
| Number\_Conc\_Update0 | Number of conceptions occurring the same month of the focal event |
| Number\_Conc\_Update1 | Mean number of conceptions occurring over the past month before the focal event |
| Number\_Conc\_Update2 | Mean number of conceptions occurring over the past 2 months before the focal event |
| Number\_Conc\_Update4 | Mean number of conceptions occurring over the past 4 months before the focal event |
| Number\_Conc\_Update6 | Mean number of conceptions occurring over the past 6 months before the focal event |
| SynchConc1 | Mean number of conceptions occurring in the 2 months surrounding the focal event |
| SynchConc2 | Mean number of conceptions occurring in the 4 months surrounding the focal event |
| SynchConc3 | Mean number of conceptions occurring in the 6 months surrounding the focal event |
| AfterConc1 | Mean number of conceptions occurring in the month after the focal event |
| AfterConc2 | Mean number of conceptions occurring in the 2 months after the focal event |
| AfterConc4 | Mean number of conceptions occurring in the 4 months after the focal event |
| AfterConc6 | Mean number of conceptions occurring in the 6 months after the focal event |
| Relative.rank | Relative rank of the female |
| Rank | Rank, as a categorical variable, of the female |
| Dif\_Rainfall0 | Non-seasonal rainfall variation in the same month (for Dif\_RainfallX, mean non-seasonal rainfall variation over the past X months, X going from 1 to 12) |
| Dif\_NDVI0 | Non-seasonal NDVI variation in the same month (for Dif\_NDVIX, mean non-seasonal NDVI variation over the past X months, X going from 1 to 12) |
| Rainfall\_Seasonality0 | Seasonal rainfall variation in the same month (for Rainfall\_SeasonalityX, mean seasonal rainfall variation over the past X months, X going from 1 to 12) |
| NDVI\_Seasonality0 | Seasonal NDVI variation in the same month (for NDVI\_Seasonality X, mean seasonal NDVI variation over the past X months, X going from 1 to 12) |
| vecConc | Randomized conception probability, taking into account the uncertainty of the conception date. 1000 randomized vectors (see main text) |

The R script ‘Model\_4’ should be self-explanatory. We first show from line 14 to 76 of the script how we computed the 1000 randomized cycle resumption dates, i.e. how we obtained the 1000 vectors of the table. We then present from line 79 to 769 the different steps of the model selection (see also Appendix D and Table S3 of the Supplementary Material). We then present from line 772 to 1088 the code used to obtain the results presented in the main text (Table 4). Finally, from line 1091 to the end of the script, we ran an alternative model, composed of variables in models for which ΔAIC were <2 (see Table S3 of the Supplementary material), and showed that it did not alter the significance of our results.

**V/ Figures of the main text and supplementary material**

In the R script ‘Figure Script’, we give the codes used to create the 3 figures of the main text, along with the second figure of the supplementary material. Note that the script to get Figure S3 and Figure S4 is shown in the R file named ‘Model Appendix E’.

For the Panel A of Figure 1 (lines 8-80), you need to use the table ‘tab\_NDVI.csv’ gathering the monthly values of NDVI in our baboon troops’ home ranges between 2004 and 2019. For the Panel B of Figure 1 (lines 50-81), you need to use the ‘infant\_mortality.csv’ table.

For Figure 2 (lines 85-130), you need to open the table ‘ForFigure2.csv’, which gathers the ΔAIC from the model selection on group reproductive synchrony for Models 3 (cycle resumption) and 4 (conception). The Panel A of Figure 2 had been done using another software and is only illustrative (no results are presented on this panel).

For the Panel A of Figure 3 (lines 137-177), you need to open the table ‘IBI\_Table.csv’ ; for the Panel B (lines 181-215), the table ‘Cycle\_Resumption\_Table.csv’ ; and for the Panel C (lines 218-254), the table ‘Conception\_Table.csv’.

Finally, for Figure S2 (lines 264 – end of the script), you need to open the file ‘Conception\_Table.csv’.

**VI/ Appendix E and Figures S3 and S4 of the Supplementary Material**

In the R script ‘Model Appendix E’, you will find the code developed to model the influence of group reproductive synchrony on the strength of reproductive seasonality in baboons (through its effect on interbirth intervals) (see Appendix E, Supplementary Material). To run this model, you need to open two tables, namely ‘Births\_Distribution.csv’ and ‘Extract\_ModelIBI\_Rank\_Synchro\_Interaction.csv’. These tables give respectively the monthly number (‘Count’) and proportion (‘Proportion’) of births in the Tsaobis baboon population, and the fitted values of our final Model 1 (presented in Table 2). From this code, you can also create Figures S3 (lines 123-157) and S4 (lines 159-196).