SUPPLEMENTAL INFORMATION

Extreme behavioural shifts by baboons exploiting risky, resource-rich, human-modified environments

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Additional information (Methods: capture)

For five days, cages were baited with corn and placed within the core home range of the study troop so that the baboons readily entered and consumed the food (corn). On the day of trapping, once the baboon was settled and feeding, the door was shut by an observer pulling a cord that released it. The baboons were anaesthetized using low impact 1.5ml plastic dart deployed from a pole (Daninject or Telinject), with 0.6ml of Ketamine (2mg/kg). Once sedated, the collar was fitted to the baboon and adjusted accordingly. The collar was made sufficiently tight so that it may not be pulled over the baboons head, nor get caught in vegetation, but sufficiently loose as to be comfortable and not hinder the animal’s respiration or ingestion and rotate around its neck freely. The smooth inner surface of the collar minimised risk of rubbing. Once the collar had been fitted the baboon was administered with 0.6ml of Medetomidine (0.02 mg/kg) in order to reverse the effects of the sedation. The baboon was then placed back into the cage until it had regained full mobility and awareness. Once recovered, it was released from the cage and re-joined the troop.

Additional information (Methods: collar failure)

Whilst we completed robust testing in the lab for our custom-designed collars, we experienced a high rate of collar failure. Two of the collars did not record and several stopped working due to water damage or due to a failure in the memory cards (details provided in Table S1). These prototype collars were significantly enhanced after this study; learning from our mistakes we created a second version that we describe in Fehlmann et al. If you are looking to replicate this work, or do something similar, please follow the full end-to-end process we describe in the supplementary material of Fehlmann et al. in order to avoid encountering the same issues we had during the study we present here.
Fig. S1. Map of study area (Methods: Risk and returns).
Map of the area given to the rangers during the interviews. Rangers were asked to colour in areas between the white lines where, in their opinion, the baboons were allowed to be: at any time (green), some of the time (orange), or never (red). Areas were defined by specific landmarks such as farm boundaries, roads or tree lines. The satellite image is issued from Google Earth (access date: 6/6/2014).
Fig. S2. Sensitivity analysis for VeDBA (Methods: Space use and activity).
Sensitivity analysis to select the time interval around a GPS fix (n=6,273) for the computation of the mean VeDBA (g). The sensitivity analysis has been carried in each different habitat type fynbos, trees, meadows, vineyards and urban (red, green, blue, cyan, magenta, respectively). The vertical line represents the time interval chosen.
Fig. S3. VeDBA comparison (Discussion).
The Vectorial Dynamic Body Acceleration (VeDBA) measured while focal baboons were running (n = 169 events, defined by video footage: Fehlmann et al. 2017) and while the baboons were in the urban area (n = 116 events, defined by GPS fixes).
Table S1. Details of the recording period for each individual in days (Methods: Baboon tracking collars).

The collars were intended to record for 50+ days but stopped working due to water damage or due to a failure in the memory cards (details provided). These prototypes were significantly enhanced in a second version that we describe in Fehlmann et al.\textsuperscript{81}. Overall, collars recorded 7,573 GPS fixes, among which 7,428 were associated with activity data and 6,322 were recorded during daytime. From those, 6,274 GPS fixes met our accuracy criterion. The collars were removed after 3 months.

| Individual | Start       | End          | Duration | Total GPS fixes | GPS fixes recorded during daytime | Reason for the interruption of data recording |
|------------|-------------|--------------|----------|-----------------|-----------------------------------|---------------------------------------------|
| M1         | 03/05/2014  | 15/05/2014   | 12       | 1,485           | 1,295                             | Memory card error                           |
| M2         | 21/05/2014  | 31/05/2014   | 10       | 1,473           | 1,183                             | Memory card error                           |
| M3         | 21/05/2014  | 06/06/2014   | 16       | 1,499           | 1,239                             | Memory card error                           |
| M4         | 30/05/2014  | 03/06/2014   | 4        | 602             | 501                               | Water damage                                |
| M5         | 31/05/2014  | 10/06/2014   | 10       | 1,391           | 1,152                             | Memory card error                           |
| M6         | 11/06/2014  | 19/06/2014   | 8        | 1,123           | 904                               | Damage to antenna                           |
Table S2. List of all food items sampled (Methods: Risk and returns).

Details of baboon food items recorded during environmental sampling. Bite size (in g) was estimated based on behavioural focal observations. Sources for the nutritional characteristics of the different food items are given in square brackets and referenced at the end of this document.

| Food Item             | Energy  | Bite size | Kcal/Bite | Size estimation | Comment                                                                 |
|-----------------------|---------|-----------|-----------|-----------------|--------------------------------------------------------------------------|
| Acacia sp., seed [S2] | 427.3   | 0.1       | 0.5       | 1 unit          | given as Acacia nicolota, seed                                           |
| Bin [S3]              | NA      | NA        | 10.0      | NA              | * estimated with vegetable/fruit peel and bread                          |
| Bread [S3]            | 266.0   | 8.8       | 23.4      | 1/5 slice       | given as white bread, commercially prepared                            |
| Bromus diandrus, seed [S3] | 352.0   | 0.1       | 0.2       | 1 unit          | given as barley, pearled, raw                                           |
| Bromus diandrus, stem [S3] | 102.9   | 0.3       | 0.3       | 1 unit          | given as barley, aerial part, fresh                                     |
| Citrus lemonum, fruit [S3] | 29.0    | 11.6      | 3.4       | 1/5 unit        | given as lemon, raw, without peel                                      |
| Egg [S3]              | 143.0   | 9.5       | 13.6      | 1/4 unit        | given as whole, raw, fresh                                              |
| Ficus sp., fruit [S3] | 74.0    | 25.0      | 18.5      | 1/2 unit        | given as fig, raw                                                       |
| Fruit [S3]            | NA      | NA        | 12.8      | NA              | * estimated with different fruits                                       |
| Hypochoeris radica, leaf [S2] | NA      | NA        | 0.4       | 3 leaves        | * estimated with leaves                                                 |
| Hypochoeris radica, root [S3] | NA      | NA        | 0.3       | 1/3 root        | * estimated with radish                                                |
| Lawn [S2]             | NA      | NA        | 0.4       | NA              | * estimated with small annuals                                          |
| Lupinus sp., leaf [S2] | 90.9    | 0.5       | 0.5       | 3 leaves        | given as Lupinus albus, aerial part, fresh                              |
| Myrtillus sp., fruit   | NA      | NA        | 2.1       | 1 unit          | * estimated with berries                                               |
| Olea sp., fruit [S3]  | 145.0   | 3.4       | 4.9       | 1 unit          | given as olive, bottled, green                                          |
| Ornithopus compressus, aerial part [S2] | NA      | NA        | 0.4       | 1 leaf          | * estimated with leaves                                                 |
| Oxalis sp., flowers [S2] | NA      | NA        | 0.4       | 1 unit          | * estimated with leaves                                                 |
| Oxalis sp., leaf [S2] | NA      | NA        | 0.4       | 5 leaves        | * estimated with leaves                                                 |
| Pennisetum clandestinum, stem [S2] | 87.5    | 0.3       | 0.3       | 1 unit          | given as aerial part, fresh                                             |
| Persea americano, fruit [S3] | 160.0   | 13.6      | 21.8      | 1/10 unit       | given as avocado, raw, all commercial variety                           |
| Pinus pinea, seed [S3] | 673.0   | 0.2       | 1.1       | 1 unit          | given as pine nut, dried                                               |
| Protea tree, seed [S3] | NA      | NA        | 0.8       | 1 unit          | * estimated with seeds                                                 |
| Psidium guajava, fruit [S3] | 68.0    | 11.0      | 7.5       | 1/5 unit        | given as guava, raw                                                     |
| Quercus sp., seed [S3] | 387.0   | 5.8       | 22.6      | 1 unit          | given as acorn, raw                                                     |
| Rahpanus raphinastrum, flower [S2] | NA      | NA        | 0.4       | 1 unit          | * estimated with leaves                                                 |
| Rahpanus raphinastrum, leaf [S2] | NA      | NA        | 0.4       | 3 leaves        | * estimated with leaves                                                 |
| Rahpanus raphinastrum, root [S3] | NA      | NA        | 0.3       | 1/3 root        | * estimated with radish                                                |
| Rosa sp., hip [S3]    | 162.0   | 3.8       | 6.2       | 1 unit          | given as rose, hip                                                      |
| Triticum sp., seed [S2] | 376.9   | 0.1       | 0.2       | 1 seed          | given for grain                                                         |
| Triticum sp., stem [S2] | 125.7   | 0.3       | 0.4       | 1 unit          | given forage, fresh                                                    |
| Veg patch [S3]        | NA      | NA        | 4.0       | NA              | * estimated with vegetables                                             |
| Vicia tetrasperma, aerial part | NA      | NA        | 0.4       | 1 unit          | * estimated with leaves                                                 |
| Vitis vinifera, fruit [S3] | 69.0    | 5.0       | 3.5       | 1 berry         | given as grape, red or green, raw                                       |
| Watsonia sp., bulb [S3] | NA      | NA        | 12.5      | 1/3 unit        | * estimated with tuberous vegetables                                    |
Table S3: Details of the witnessed raids (Results: Baboon raiding strategy).
Data or raiding was opportunistically recorded during the study period (from the 03/04/2014 to the 21/07/2014, i.e. 109 days).

| Target                | Number of raids |
|-----------------------|-----------------|
| Bin                   | 57              |
| Restaurant            | 23              |
| Garden                | 7               |
| People                | 6               |
| Car                   | 4               |
| Unattended Backpack   | 2               |
| House                 | 2               |
| Not identified        | 4               |
| **Total**             | **105**         |
Supplemental References

S1. Fehlmann, G., O’Riain, M. J., Hopkins, P. W., O’Sullivan, J., Holton, M. D., Shepard, E. L. C., King, A. J. (2017) Identification of behaviours from accelerometer data in a wild social primate. *Animal Biotelemetry* 5:6.

S2. U.S. Department of Agriculture (2015) USDA National Nutrient Database for Standard Reference.

S3. Johnson, C. A., Raubenheimer, D., Rothman, J. M., Clarke, D. & Swedell, L. (2013) 30 days in the life: daily nutrient balancing in a wild chacma baboon. *PLoS One* 8, e70383.
Source code

This document provides all R codes used for all analyses of data presented in:

*Extreme behavioural shifts by baboons exploiting risky, resource-rich, human-modified environments*

To use these scripts requires the following R packages:

```r
library(vegan)
library(dunn.test)
library(MASS)
library(nlme)
library(plyr)
```

**To test differences in energy availability and VeDBA according to habitat type (prediction 1)**

Loading the data

```r
grid=read.csv("EnvironmentData.csv")
```

Kruskal Wallis Test

```r
kruskal.test(FoodAvail~Habitat, data=grid)
```

```
##
##  Kruskal-Wallis rank sum test

## data:  FoodAvail by Habitat
## Kruskal-Wallis chi-squared = 51.698, df = 4, p-value = 1.595e-10
```

⇒ Food availability varies according to habitat type

```r
dunn.test(grid$FoodAvail,grid$Habitat, method="bonferroni")
```

```
##  Kruskal-Wallis rank sum test

## data:  x and group
## Kruskal-Wallis chi-squared = 51.698, df = 4, p-value = 0
```
Comparison of x by group
(Bonferroni)

## Col Mean -
## Row Mean | Fynbos    Meadows      Trees      Urban
##          | --------------------------------------------
## Meadows | -0.560504
##          | 1.0000
## Trees   | 0.005437   0.534968
##          | 1.0000     1.0000
## Urban   | 4.724985   4.454984   4.315772
##          | 0.0000     0.0000     0.0001
## Vineyard| -0.562177   0.218405   -0.506213   -6.946080
##          | 1.0000     1.0000     1.0000     0.0000

To investigate relationships between the risk of deterrence by rangers and habitat type (prediction 2)

Generating distance matrices:

```r
distsrisk <- dist(grid$Risk)
distshabitat <- dist(grid$HabLevel)
dists <- as.matrix(dist(cbind(grid$Lat, grid$Long)))
dists.inv <- 1/dists
diag(dists.inv) <- 0
```

Computing the Mantel test with 10 000 permutations:

```r
mantel.partial(distsrisk, distshabitat, dists.inv,
               method = "spearman", permutations = 10000)
```

## Partial Mantel statistic based on Spearman's rank correlation rho
## Call:
mantel.partial(xdis = distsrisk, ydis = distshabitat, zdis = dists.inv,
               method = "spearman", permutations = 10000)
## Mantel statistic r: 0.6598
## Significance: 9.999e-05
## Upper quantiles of permutations (null model):
## 90% 95% 97.5% 99%
## 0.0271 0.0365 0.0451 0.0558
## Permutation: free
## Number of permutations: 10000
risk of deterrence by rangers and habitat type are highly correlated (controlling for spatial autocorrelation)

**Kruskal Wallis test to see whether VeDBA (activity levels) changed according to habitat type (prediction 3)**

Loading the data:

```r
GPSi = read.csv("CollarData.csv")
```

VeDBA and Habitats:

```r
kruskal.test(VeDBA~Habitat, data=GPSi)
```

```r
##  Kruskal-Wallis rank sum test
## data:  VeDBA by Habitat
## Kruskal-Wallis chi-squared = 576.34, df = 4, p-value < 2.2e-16
```

VeDBA varies according to habitats

```r
dunn.test(GPSi$VeDBA, GPSi$Habitat, method="bonferroni")
```

```r
##  Kruskal-Wallis rank sum test
## data: x and group
## Kruskal-Wallis chi-squared = 576.3351, df = 4, p-value = 0
##
## Comparison of x by group (Bonferroni)
## Col Mean- | Fynbos | Meadows | Trees | Urban
## Row Mean |         |         |       |       |
##----+-------------------+---------+--------+--------
##   +--------------------------------------------
##  Meadows | 1.514556
##          | 0.6494
##  Trees   | -1.991446         -12.03757
##          | 0.2322            0.0000
##  Urban   | 6.308603          8.325330   13.82481
##          | 0.0000            0.0000    0.0000
## Vineyard| 2.228992          2.342222   21.06535
##          | 0.1291            0.0958    0.0000    0.0000
Linear Mixed Model to investigate if VeDBA changed as a function of risk of deterrence by rangers (prediction 3).

Using Boxcox method to identify best transformation:

```R
box = boxcox(lm(VeDBA ~ Risk, data = GPSi), lambda = seq(-0.1, 0, by = 0.001))
```

```r
box[[1]][which(box$y == max(box$y))]
## [1] -0.042
```

⇒ Use Log transformation

```r
GPSi$VeDBA.tr = log(GPSi$VeDBA)
```

Linear Mixed Model (LMM) with Individual as a random effect:

```R
VOm1 = lme(VeDBA.tr ~ Risk, random = ~ 1 + Risk | ID, data = GPSi)
```

Investigating the need for a model taking into account spatial auto-correlation:

```R
plot(Variogram(VOm1, form = ~ Long + Lat))
```
The presence of a slope indicates the effect of spatial auto-correlation in the data

Testing the different auto-correlation methods:

```r
VOm1spcorr1a <- update(VOm1, correlation = corExp(form = ~ jitter(Lat) + Long, nugget = T))
VOm1spcorr2a <- update(VOm1, correlation = corRatio(form = ~ jitter(Lat) + Long, nugget = T))
VOm1spcorr3a <- update(VOm1, correlation = corSpher(form = ~ jitter(Lat) + Long, nugget = T))
VOm1spcorr4a <- update(VOm1, correlation = corLin(form = ~ jitter(Lat) + Long, nugget = T))
VOm1spcorr5a <- update(VOm1, correlation = corGaus(form = ~ jitter(Lat) + Long, nugget = T))
```

```r
anova(VOm1spcorr1a, VOm1spcorr2a, VOm1spcorr3a, VOm1spcorr4a, VOm1spcorr5a, test = F)
```

```
##            Model df      AIC      BIC    logLik
## VOm1spcorr1a     1  8 15446.01 15499.96 -7715.007
## VOm1spcorr2a     2  8 16422.56 16476.51 -8203.281
## VOm1spcorr3a     3  8 16422.56 16476.51 -8203.281
```
## VOm1spcorr4a
4 8 16422.56 16476.51 -8203.281
## VOm1spcorr5a
5 8 16421.83 16475.78 -8202.916

⇒ Selection of the exponential correlation form

```r
anova(VOm1, VOm1spcorr1a)
```

## VOm1             1  6 16418.56 16459.03 -8203.281
## VOm1spcorr1a     2  8 15446.01 15499.96 -7715.007 1 vs 2 976.549 <.0001

⇒ Selection of the model taking into account spatial-autocorrelation over the simple mixed model

Investigating individual effects as a random factor:

```r
VOm1spcorr1a <- lme(VeDBA.tr ~ Risk, random = ~ 1 + Risk | ID, correlation = corExp(form = ~ jitter(Lat) + Long, nugget = T), data = GPSi)
VOm1spcorr1b <- lme(VeDBA.tr ~ Risk, random = ~ 1 | ID, correlation = corExp(form = ~ jitter(Lat) + Long, nugget = T), data = GPSi) #best
VOm1spcorr1c <- gls(VeDBA.tr ~ Risk, correlation = corExp(form = ~ jitter(Lat) + Long, nugget = T), data = GPSi)
```

```r
anova(VOm1spcorr1a, VOm1spcorr1b, VOm1spcorr1c)
```

## VOm1spcorr1a     1  8 16422.46 16476.41 -8203.229
## VOm1spcorr1b     2  6 15441.05 15481.51 -7714.526 1 vs 2 977.4071 <.0001
## VOm1spcorr1c     3  5 16717.01 16750.72 -8353.502 2 vs 3 1277.9534 <.0001

Chosen model:

```r
VOm1spcorr1b <- lme(VeDBA.tr ~ Risk, random = ~ 1 | Ind, correlation = corExp(form = ~ jitter(Lat) + Long, nugget = T), data = GPSi)
```

Checking model assumptions:

```r
VOm = VOm1spcorr1b
resid = resid(VOm)
pr = predict(VOm)
```
To compare focal baboon activity budgets to those published in the literature (prediction 5)

Loading study data:

```r
TBudg = read.csv("TimeBudget.csv", header=T)
percent = prop.table(as.matrix(TBudg[, 2:5]), 2) * 100
colnames(percent) = c("Soc.p", "Res.p", "Mov.p", "For.p")
TBudg = cbind(TBudg, percent)
TBudg = TBudg[TBudg$ID != "OR",] # Individual died during the study
```

Data from literature:

```r
TBudgStrum = data.frame(Feeding = c(mean(33.68, 28.33, 24.31, 25.86, 24.12, 38.12),
                                     mean(61.29, 37.98, 54.50, 56.57, 45.93, 41.66)),
                         ID = c("WBY", "PHG"),
             `
Strat=c("Raiders","Non Raiders"), Origin="Kenya")

TBudgAltmann=data.frame(Feeding=c(22,65,60), ID=c("LDG","HOK","ALT"),
Strat=c("Raiders","Non Raiders","Non Raiders"), Origin="Kenya")

TBudgKenya=rbind(TBudgAltmann,TBudgStrum)
TBudgKenya$ID=as.character(TBudgKenya$ID)
TBudgKenya$Origin=as.character(TBudgKenya$Origin)
TBudgKenya$Strat=as.character(TBudgKenya$Strat)
TBudgKenya=TBudgKenya[order(TBudgKenya$Feeding),]

TBudgHoffman=data.frame(Feeding=c(27.3,55,23.1,52.0),
ID=c("RH","BB","TK","KK"), Strat=c("Raiders","Non Raiders", "Raiders","Non Raiders"), Origin="Cape Peninsula")

TBudgHoffman$ID=as.character(TBudgHoffman$ID)
TBudgHoffman$Origin=as.character(TBudgHoffman$Origin)
TBudgHoffman$Strat=as.character(TBudgHoffman$Strat)
TBudgHoffman=TBudgHoffman[order(TBudgHoffman$Feeding),]

AllData=data.frame(Feeding=c(TBudg$For.p,TBudgHoffman$Feeding,
TBudgKenya$Feeding), Location=as.factor(c(rep("Males",nrow(TBudg)
),rep("Others",nrow(TBudgHoffman)+nrow(TBudgKenya)))))

Kruskal Wallis test:

kruskal.test(AllData$Feeding ~ AllData$Location)

##
##  Kruskal-Wallis rank sum test
##
## data:  AllData$Feeding by AllData$Location
##  Kruskal-Wallis chi-squared = 13.5, df = 1, p-value = 0.0002386

⇒ Focal males forage less than baboons elsewhere.