

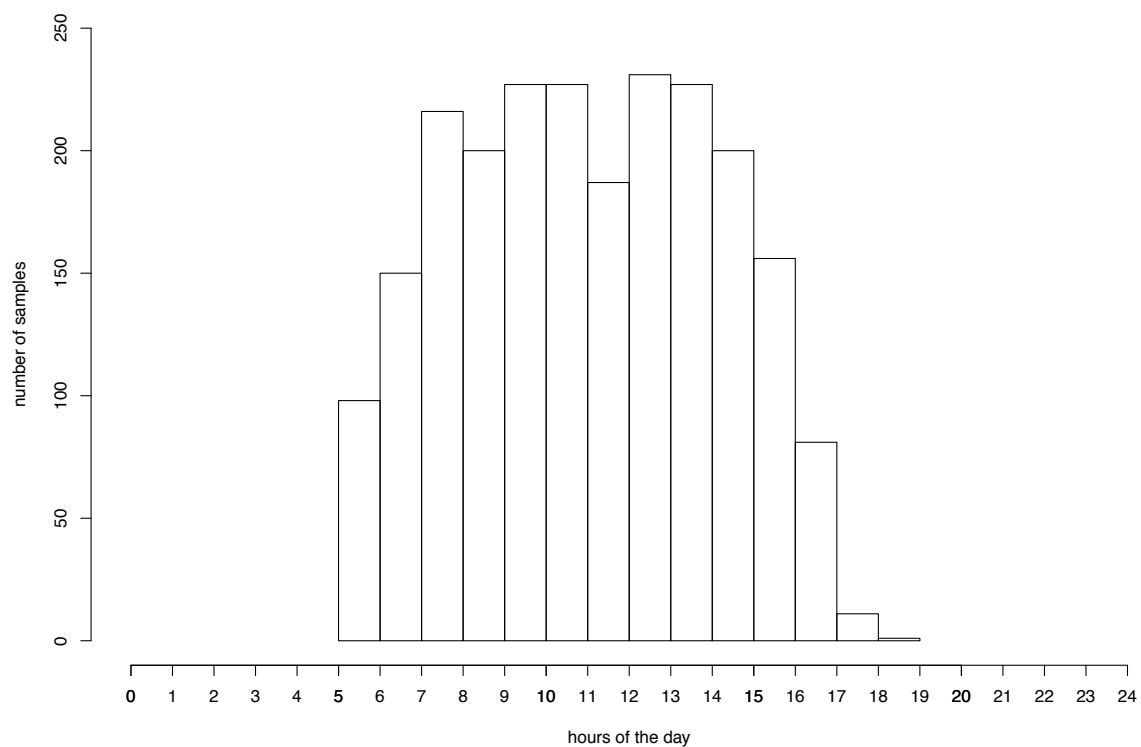
## Supplementary material

**Table S1:** Number of males per age and sample numbers by age and group. Adult males between 15 and 49 years of age were included in the study.

age	Number of males	number of samples Sonso	Number of samples Taï	number of samples Taï - East	number of samples Taï - North	number of samples Taï - South
15	13	55	117	30		87
16	9	102	93	22		71
17	10	77	212	53	4	155
18	4	54	79		2	77
19	7	8	92	27	5	60
20	6	25	136	40	6	90
21	4	29	157	117		40
22						
23						
24	2	18				
25	2	36				
26	2	97				
27	3	43	5			5
28	1		22			22
29	1		13			13
30	1		1	1		
31	5		29	21		8
32	5		61	43		18
33	3		15	15		
34						
35						
36	1		34	34		
37	1		91	91		
38	1		69	69		
39						
40	2	1	1			1
41	3	10	17			17
42	3	8	15			15
43	1	8				
44	1		9			9
45	1		16			16
46	1	5				
47	1	17				
48	1	6				
49	1	18				

### Urine sample collection and storage.

When an individual was sitting in a tree a plastic bag tied over a forked stick was held into the urine stream to collect the urine. If urination happened on the ground, the sample was collected once the male had moved away and taken only if the urine was not contaminated with feces. Furthermore, the sample was collected only if the collection area was not contaminated with urine from another individual to avoid cross-contamination. Samples were pipetted from the bag or from leaf off the ground into a 5 ml cryovial. To avoid degradation of hormone concentrations, urine samples were then kept cold by putting them into a thermos flask containing frozen cool packs and upon arrival at the camp frozen in liquid nitrogen. This happened within twelve hours after collection. Samples were shipped frozen (either on dry ice or in liquid nitrogen) to the Laboratory of Endocrinology at the Max Planck Institute for Evolutionary Anthropology, Germany, and stored at  $-80^{\circ}\text{C}$  until analysis.



**Figure S1:** Histogram for numbers of samples collected by hours of the day. The x-axis shows the time of the day, from 0:00 to 24:00. On the y-axis, the number of samples collected within a given hour is indicated. Most samples were collected between 8:00 and 17:00 with around 124 – 208 samples for each one hour time interval. Fewer samples were available for the time between 6:00 and 8:00 as well as for the hour between 17:00 and 19:00 with 2 to 71 samples per one hour interval.

**Table S2:** Samples per hourly intervals by group. During all hours of the day, between 6:00 and 20:00, samples were collected, allowing for representing the circadian rhythm in excreted urinary cortisol.

Hours	Sonso	Taï - East	Taï - North	Taï - South
6:00-7:00		24	1	2
7:00-8:00	22	33	3	46
8:00-9:00	63	54	1	66
9:00-10:00	79	38		74
10:00-11:00	73	54	1	58
11:00-12:00	68	59	2	65
12:00-13:00	67	52	1	67
13:00-14:00	77	56	1	45
14:00-15:00	66	66	1	74
15:00-16:00	53	56	2	62
16:00-17:00	40	43	2	61
17:00-18:00	9	19	2	47
18:00-19:00		9		36
19:00-20:00		1		1

**Table S3:** Number of samples per time interval and male. The first column indicates the community an individual male belonged to. S1-S13 were adult male chimpanzees of the Sonso community in Uganda, T1-T17 were males from one of the three communities in Taï. From the third to the last column the numbers of urine samples available per male and hourly time interval is shown. Crucially, although some cells have missing values and some males had only one sample in some time intervals, for the majority of the males several sample repeats were available for most hours of the day between 6:00 and 18:00.

group	ID	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Sonso	S1			2	6	4	1	1	2			1	1		
Sonso	S2			1	5	8	3	4	2	1	7	7	5		
Sonso	S3				3	2	2		1	1					
Sonso	S4				8	3	2	4		1				1	
Sonso	S5			1	1	2	3	8	9	12	8	6	6	2	
Sonso	S6			2	2	6	6	4	5	4	6	4	1		
Sonso	S7			1	1	5	4		1	4	1	1			
Sonso	S8			3	6	9	10	9	13	15	8	8	7	2	
Sonso	S9			6	12	19	17	9	15	14	10	11	6	2	
Sonso	S10			1	2	1					1				
Sonso	S11			1	3	10	9	13	9	10	10	4	7	1	
Sonso	S12			3	7	8	6	4	6	3	4	4		1	
Sonso	S13			1	7	2	10	12	4	12	11	7	7		
Taï - East	T1		8	11	25	18	16	22	20	17	24	12	15	5	3
Taï - East	T2								2	2	1	3	1	1	

Taï - East	T3		11	18	19	16	23	22	15	18	26	23	14	8	5
Taï - East	T4		1				2	1	3	6	2	4	2	1	
Taï - East	T5		2				2	1	3	1	1	6	4	2	1
Taï - East	T6		2	4	10	4	11	13	9	12	12	8	6	2	
Taï - North	T7		1	3	1	1		2	1	1	1	2	2	2	
Taï - South	T8			2		1	2	1	2	1	2	3	1	1	
Taï - South	T9			3	3	4	2	1	3	1	4	2	1	3	
Taï - South	T10		4	13	16	12	13	18	8	21	16	9	11	5	
Taï - South	T11		4	8	9	6	7	3	5	3	7	5	4	4	1
Taï - South	T12		2	15	11	20	13	17	13	16	13	18	11	4	
Taï - South	T13	2	10	15	5	4	10	7	4	8	4	5	4	6	
Taï - South	T14			5		4		4	2		2	2	3	1	1
Taï - South	T15		6		2	1			1	1	1	2			
Taï - South	T16		11	3	14	5	11	12	6	14	9	12	12	8	
Taï - South	T17		4	7	10	5	3	6	3	7	3	4	2	4	

**Table S4:** Overview of average rainfall and average precipitation per month across all years and sites. The first column indicates the month. In the second and third column, average temperature (in °C, and standard deviation) and average rainfall (in mm, and standard deviation) for Budongo are presented. The third and the fourth column show the data for Taï.

	Budongo	Budongo	Taï	Taï
month	Average temperature (°C) (SD)	Average rainfall (mm) (SD)	Average temperature (°C) (SD)	Average rainfall (mm) (SD)
January	22.18 (0.14)	3.12 (0.74)	21.95 (1.05)	1.12 (2.38)
February	22.64 (0.46)	3.08 (0.53)	24.03 (0.29)	3.67 (2.13)
March	24.07 (0.35)	5.23 (0.74)	23.59 (0.26)	6.11 (1.30)
April	23.17 (0.36)	6.95 (2.08)	23.85 (0.28)	6.03 (1.76)
May	22.33 (0.29)	5.45 (1.17)	24.06 (0.39)	6.34 (1.87)
June	21.71 (0.30)	3.51 (0.81)	22.95 (0.27)	6.91 (0.11)
July	21.15 (0.49)	4.10 (0.79)	22.37 (0.26)	3.71 (5.68)
August	21.63 (0.31)	7.15 (2.95)	22.51 (0.04)	4.79 (2.00)
September	21.97 (0.25)	5.40 (0.25)	23.07 (0.16)	9.89 (3.00)
October	22.31 (0.34)	6.07 (2.26)	23.12 (0.58)	10.99 (5.42)
November	22.45 (0.29)	4.78 (2.49)	23.72 (0.33)	4.42 (1.35)
December	21.82 (0.76)	2.42 (1.94)	23.02 (0.25)	3.13 (2.86)

**Table S5:** Model structures. Log-transformed measures of urinary cortisol levels corrected for creatinine content were used as the response variable. Control variables, all mean centered and standardized to two standard deviations, were included. In the first model, random intercepts were included for male identity, the dummy variable “male year”, the dataset, the year, and the month, allowing for estimation of trait repeatability. In the second model, random slopes for mean centered and standardized linear and quadratic effects of time of day were included for male identity and “male year” in addition.

Model parameter	Variable
Response	Log-transformed urinary cortisol levels corrected for creatinine
Control (all variables mean centered and standardized to two standard deviations)	Time of sample collection squared Dominance rank Age at sampling Sex ratio within group Group identity Average monthly rainfall in interaction with Time of sample collection Average monthly temperature
Random intercepts (included in “intercept model” and “slope model”)	Male identity Dummy variable “male year” Dataset Year Month
Random slopes (included in “slope model”)	Mean centered linear and quadratic effects of time of day for male identity Mean centered and standardized linear and quadratic effects of time of day for “male year”

**Table S6:** Model results for control variables. All variables were mean centered and standardized to two standard deviations. Please note that models were fit with a random effects structure that allows to quantify between and within individual variation in circadian urinary cortisol patterns while controlling but not testing for potential influence of several social and ecological variables (fixed effects). Thus, significance of the influence of fixed effects on urinary cortisol levels cannot be inferred from these models.

<b>Fixed effects of intercept model</b>			
	Estimate	Standard Error	t-value
Intercept	4.24407	0.26696	15.898
Time squared	- 0.21500	0.06373	- 3.374
Dominance rank	0.09341	0.07701	1.213
Sex ratio	- 0.29731	0.08042	- 3.697
Age	0.23909	0.09243	2.587
Group identity	- 0.40790	0.34101	- 1.196
Average rainfall	- 0.03057	0.04268	- 0.716
Time	- 0.59104	0.03122	- 18.932
Average temperature	- 0.13712	0.05886	
Average rainfall * time	0.10734	0.05348	
<b>Fixed effects of slope model</b>			
Intercept	4.22904	0.26625	15.884
Time squared	-0.21976	0.08107	- 2.711
Dominance rank	0.09179	0.07626	1.204
Sex ratio	- 0.29065	0.07939	- 3.661
Age	0.16488	0.09139	1.804
Group identity	- 0.39172	0.33844	- 1.157
Average rainfall	- 0.02903	0.04229	- 0.686
Time	- 0.56516	0.05140	- 10.995
Average temperature	- 0.13748	0.05844	- 2.353
Average rainfall * time	0.08545	0.05642	1.515

#### **Model excluding the time squared variable.**

As we could not assume a linear relationship between time of the day and urinary cortisol, we added the variable time squared to our model. Here we present the same model containing the linear time variable (mean centered and standardized to two standard deviations) only (see Table S6 for model results). The two models (containing and lacking the time squared term)

are significantly different from each other (Chi-square=19.99, df=7, p=0.006), with the model containing the time squared term fitting the data better than the reduced model.

Based on the variances calculated in the reduced model, the following repeatability scores were estimated: average reaction norm repeatability = 0.67 (lCI = 0.54, uCI = 0.78), reaction norm plasticity repeatability = 0.69 (lCI = 0.56, uCI = 0.80).

**Table S7:** Results for the reduced model, containing the linear time variable only. The model is based on 1901 observations for 30 males.

	Random slope model containing the linear time term
<b>Fixed effects</b>	<b><math>\beta</math> (95% CI)</b>
Intercept	4.20 (3.66, 4.72)
Time	-0.56 (-0.66, -0.46)
Dominance rank	0.10 (-0.04, 0.26)
Sex ratio	-0.34 (-0.50, -0.19)
Age at sample	0.19 (0.00, 0.38)
Group identity	-0.41 (-1.11, 0.28)
Rainfall	-0.02 (-0.10, 0.07)
Temperature	-0.14 (-0.25, -0.03)
Rainfall * time	0.11 (0.00, 0.21)
<b>Random effects</b>	
Variance male-ID intercept	0.08 (0.05, 0.13)
Variance male-ID slope for time	0.03 (0.02, 0.04)
Variance male-year intercept	0.04 (0.03, 0.05)
Variance male-year slope for time	0.01 (0.01, 0.02)
Variance year	0.01 (0.00, 0.01)
Variance month	0.05 (0.02, 0.09)
Residual variance	0.38 (0.36, 0.41)