

Cascading effects of conspecific aggression on oxidative status and telomere length in zebra finches

ESM1: Controlling for the origin of birds

Table S1: Relative percentage of birds depending on their origin. N(total) = 36, N(high) = 24; N(low) = 12. **Lab Paris:** laboratory animal house, University of Paris Descartes, France. **Lab DEPE:** our own rearing facility, University of Strasbourg, France. **Oisellerie du Temple:** pet store, L'Isle d'Abeau, France. **Botanic:** pet store, Strasbourg, France. **Naturama:** pet store, Strasbourg, France

%	All birds	High density	Low density
Lab Paris	13.9	12.5	16.7
Lab DEPE	13.9	12.5	16.7
Oisellerie du Temple	55.6	58.3	50.0
Botanic	8.3	8.3	8.3
Naturama	8.3	8.3	8.3

ESM2: Controlling for potential collinearity of variables assessing aggression.

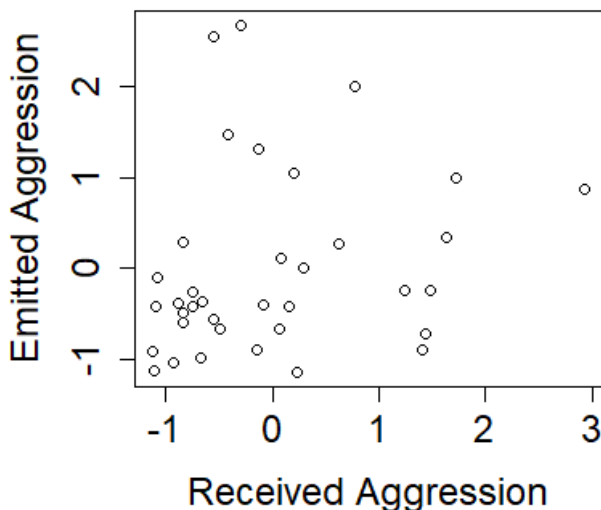


Figure S1: Correlation between received and emitted aggressions in zebra finches. Received and emitted aggressions are calculated by counting the number of aggressive behaviors per hour per bird (n=36). No statistical correlation was found (Pearson's correlation: $r = 0.21$ $t = 1.28$, p -value = 0.21).

ESM3: Individual change in relative telomere length (rTL) over the course of the experiment.

In our experiment, individual trajectories were heterogeneous with birds showing shortened, or preserved, or lengthened telomeres at the end of the 64-day long experiment. On average the change in rTL was slightly positive (mean \pm SE = 0.17 ± 0.12), suggesting that most birds partly reconstructed their telomeres over the course of the experiment (**Fig. S2**). The idea that telomeres erode constantly over time is largely challenged presently by longitudinal dataset (Brown *et al.* 2021, Fairlie *et al.* 2016, Spurgin *et al.* 2017). In this context, the negative association between telomere length and oxidative markers cannot be interpreted as only a stronger reduction in telomere length, but also as a lesser ability to maintain and reconstruct them.

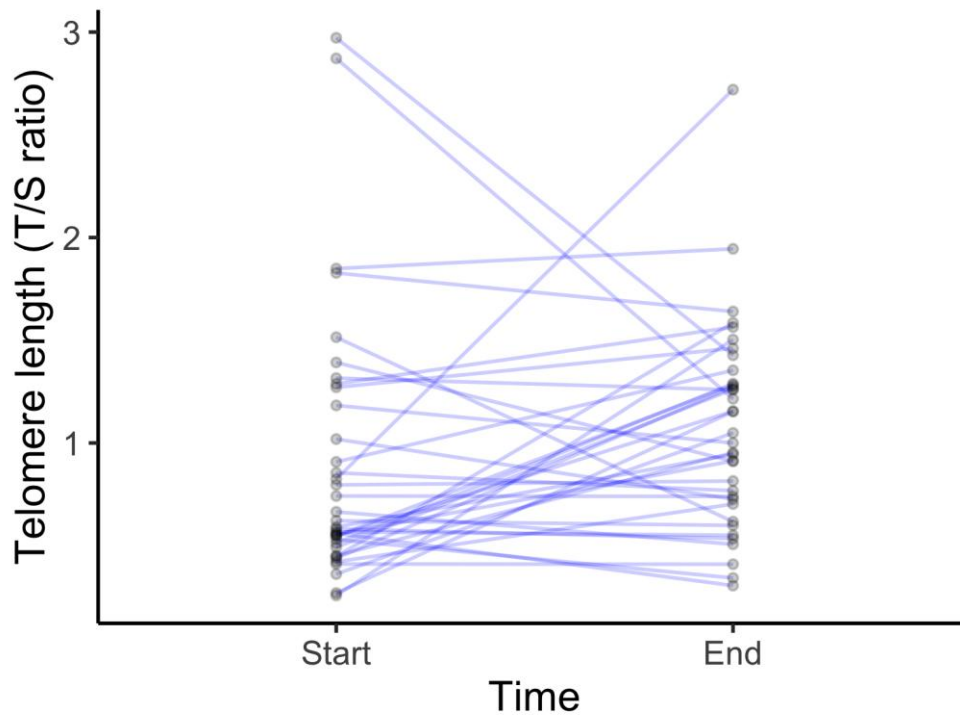


Fig. S2. Individual rTL at the start and end of the experiment in zebra finches. Blue lines depict individual trajectories.

References

- Brown TJ, Spurgin LG, Dugdale HL, et al. 2021. Causes and consequences of telomere lengthening in a wild vertebrate population. *Molecular Ecology*, *in press*.
- Fairlie J, Holland R, Pilkington JG, et al. 2016. Lifelong leukocyte telomere dynamics and survival in a free-living mammal. *Aging Cell* 15: 140–8.
- Spurgin LG, Bebbington K, Fairfield EA, et al. 2017. Spatio-temporal variation in lifelong telomere dynamics in a long-term ecological study. *J Anim Ecol*.

ESM4: Controlling for potential sex-specific differences in the physiological response.

To address the potential influence of sex on the physiological response of zebra finches to social aggressions, we ran two separate path analyses depending on bird sexes (see below **Fig. S3**). Although the value of the standardized coefficients varied slightly between males and females, the significant variables remained the same in both models. Hence, we concluded that males and females showed in our experiment a similar response to social aggression, and we therefore pooled sexes in the path analyses (see main text).

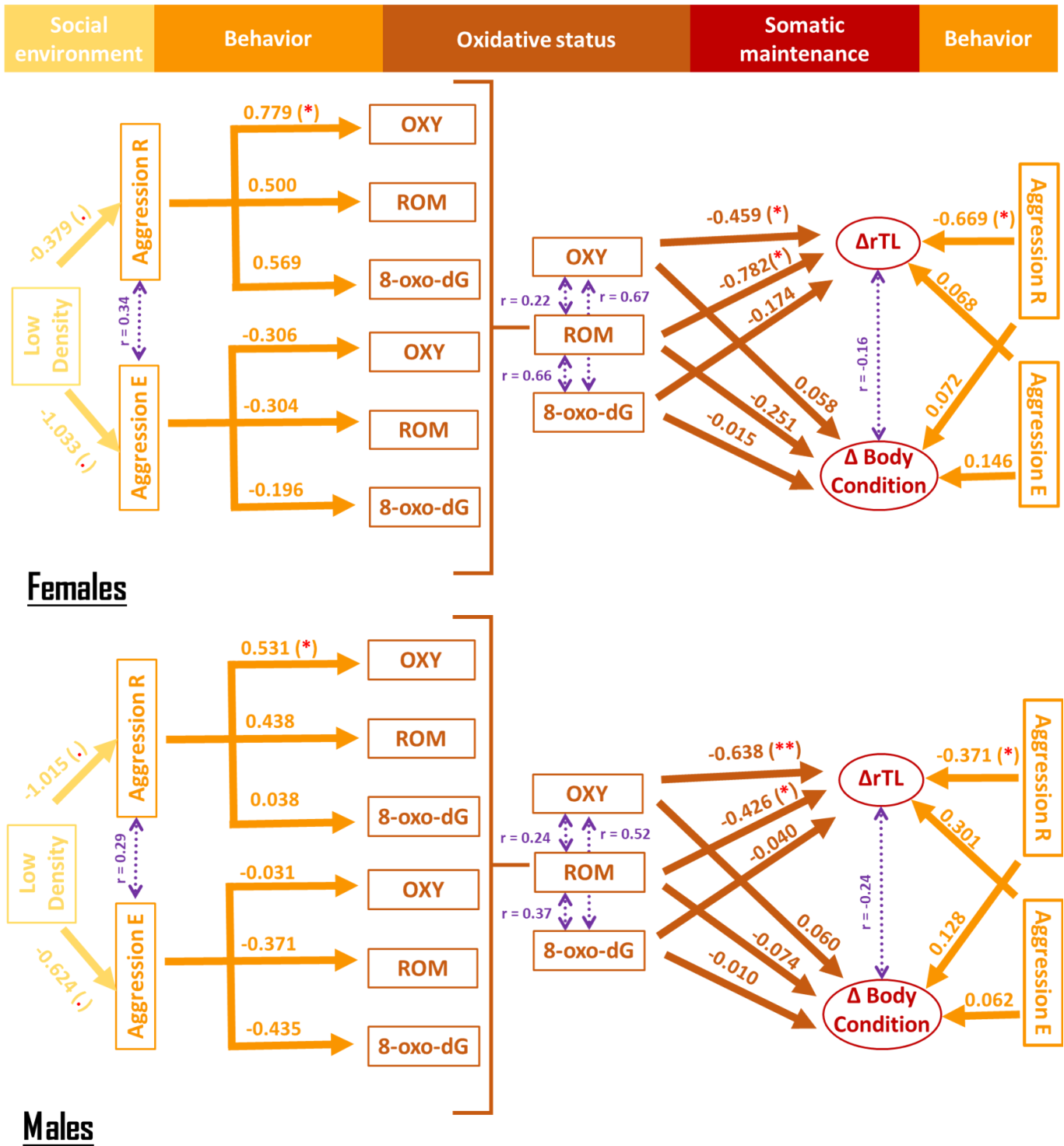


Fig. S3. Path analysis with females only (above) or males only (below). Values above the solid arrows are β path coefficients (standardized estimates). Correlation coefficients (Pearson's r) are given above double-headed dashed arrows. ΔrTL and Δ Body Condition represent the variation between the start and end of the experiment in, respectively, relative telomere length and body condition (final value – initial value). Aggression R and Aggression E are respectively the number of aggressive behaviors received and emitted, divided by the duration a bird was observed. Some variables are duplicated on the graph, but this has been done only for ease of reading. Each variable is involved only once in a given model. 18 males and 18 females. VIF_{max} (females) = 1.54 and VIF_{max} (males) = 1.35. Significance thresholds: “.”: $p < 0.1$, “*”: $p < 0.05$, “**”: $p < 0.01$.

ESM5: Considering alternatives to the full causal model

We first considered the full causal model below (Fig. S3) representing the interactions among the observed variables involved in our analysis. As shown below, the low density appears to have a weak negative effect on both emitted and received aggression. Moreover, as the behavior of birds might be completely different between the two conditions, we decided to perform two distinct analyses, one for each density condition, resulting in the same path diagram as in Fig. S3 but without density.

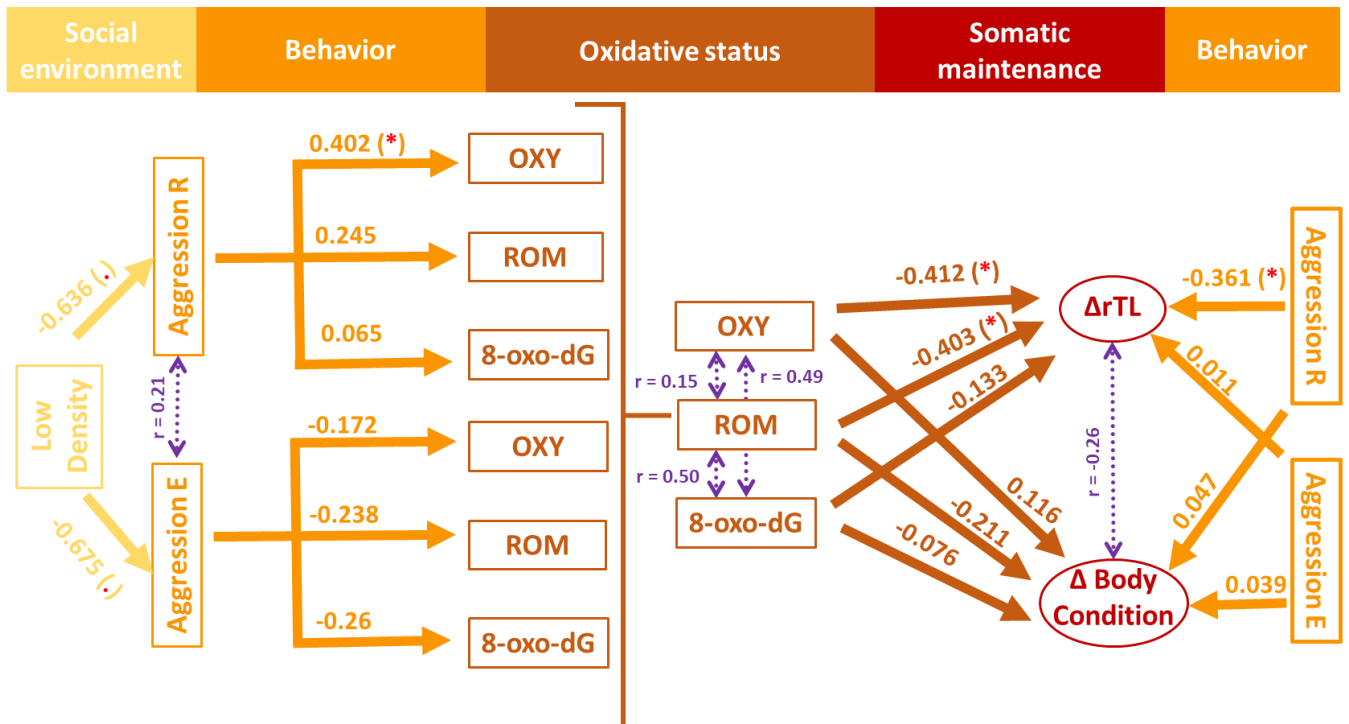


Fig. S4 Full causal model. Values above the solid arrows are path coefficients (standardized estimates). Correlation coefficients (Pearson's r) are given above double-headed dashed arrows. ΔrTL and Δ Body Condition are the variation between the start and end of the experiment in, respectively, relative telomere length and body condition. Aggression R and Aggression E are respectively the number of aggressive behaviors received and emitted, divided by the time a bird was observed. Some variables are duplicated on the graph, but this has been done only for ease of reading. Each variable is involved only once in a given model. For all models: $N = 36$ and $VIF_{max} = 1.99$. Significance thresholds: ".": $p < 0.1$, "*": $p < 0.05$, "***": $p < 0.01$.

Model	Sample size	R^2	χ^2	AIC
1. full model	36	0.052	11.2	700.5
without BC		0.097	11.1	593.2
2. low density only	12	0.131	3.8	219.9
without BC		0.143	1.7	179.3
3. high density only	24	0.104	6.3	482.8
without BC		0.152	5.9	414.8

Table S2 Alternative causal models. R^2 : geometric mean of coefficient of determination (R^2) for all regressions for a given causal model = a goodness-of-fit indicator. χ^2 = Chi-square test statistic. AIC = Akaike's Information Criterion. A better fit is indicated by a higher average R^2 , lower χ^2 , and lower AIC. BC: body condition. Indices were calculated by semnr package, function

All goodness-of-fit estimators (Table S2) show that models with both densities analyzed separately lead to better models (increase in R^2 geometric mean, decrease in χ^2 and AIC). Moreover, social density appears to trigger strong responses not highlighted in low density. Regarding, body condition, in all models tested, removing body condition resulted in increasing the R^2 , and decreasing χ^2 and AIC. We thus removed the body condition from our path analysis, and analyzed density groups separately, ending up with the causal models shown in the main text (Fig. 2).