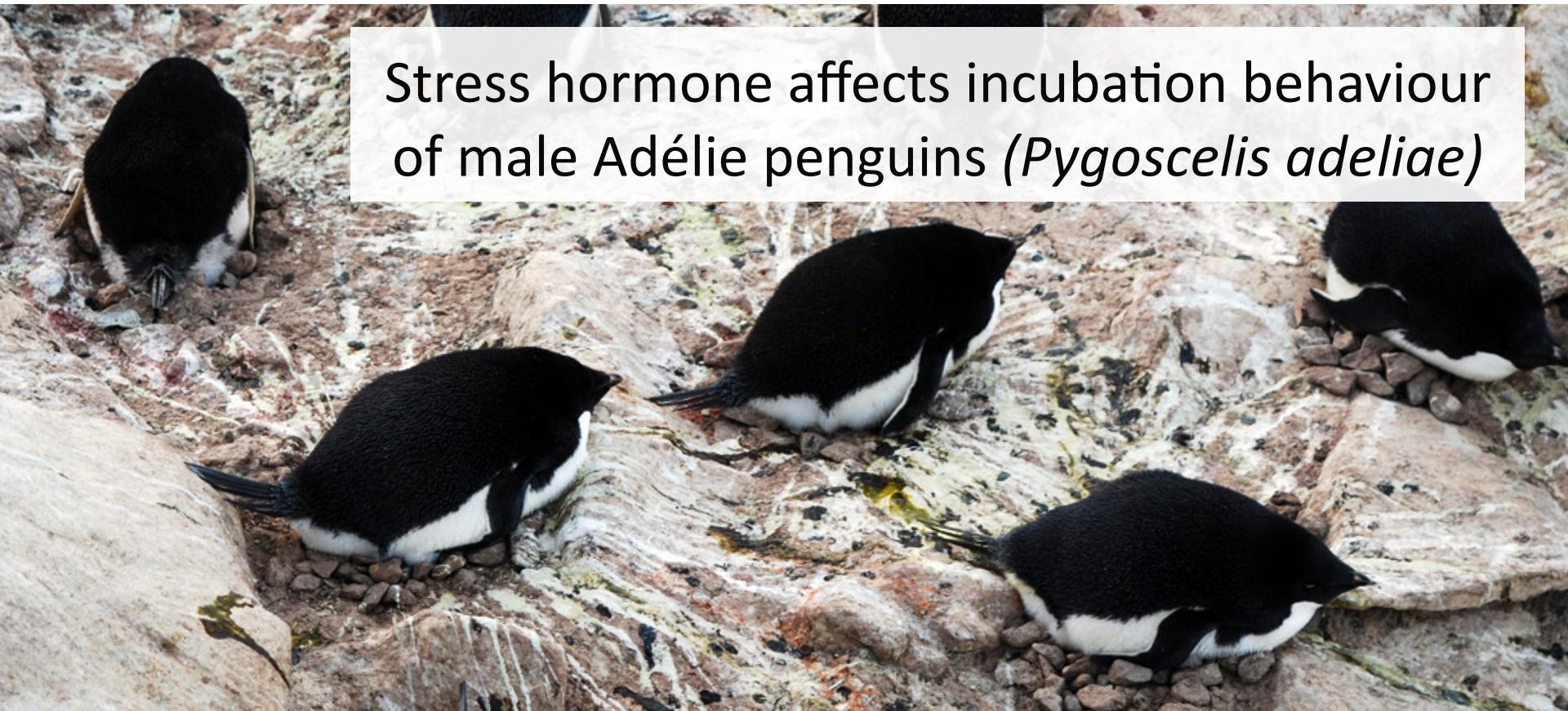


Stress hormone affects incubation behaviour of male Adélie penguins (*Pygoscelis adeliae*)



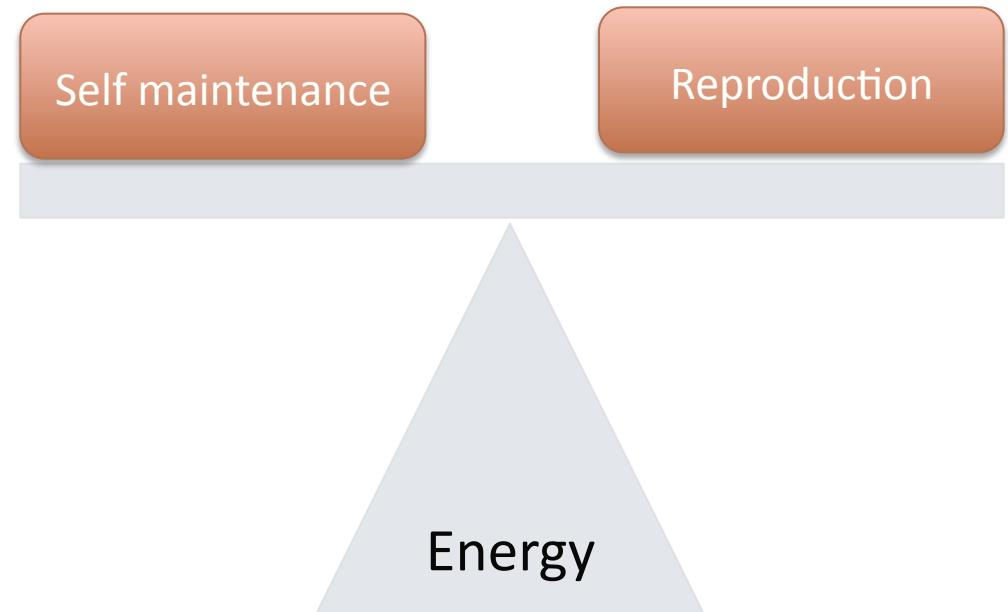
Thierry A-M, Massemin S, Handrich Y, Le Maho Y, Kato A and Raclot T.

Background 1/2

- Limited resources

Life history trade-offs

Stearns 1992

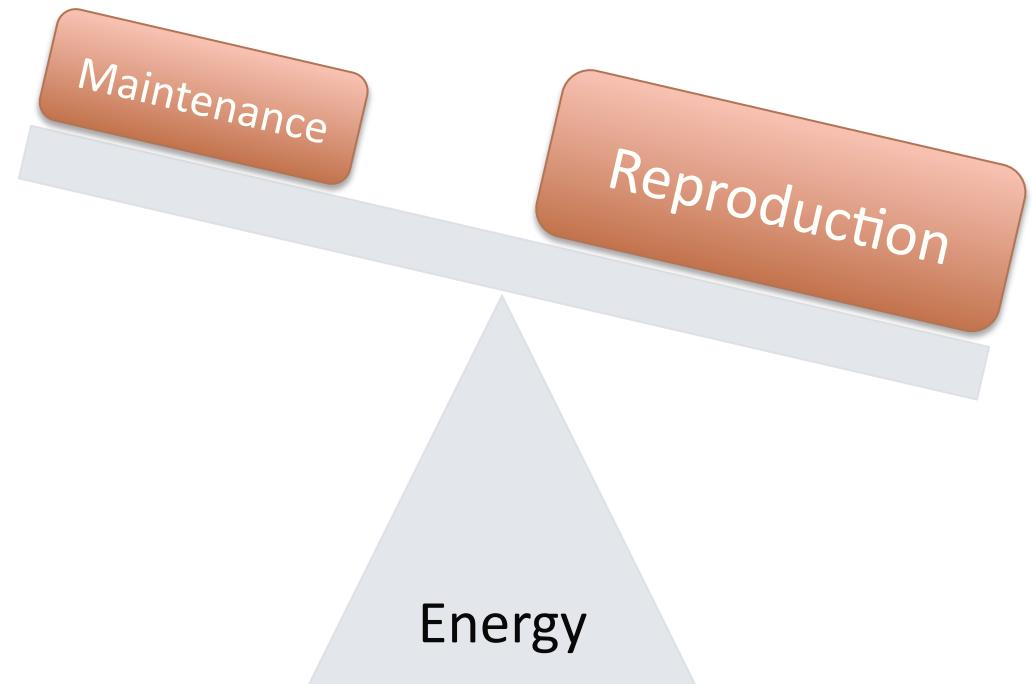


Background 1/2

- Limited resources

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Stearns 1992

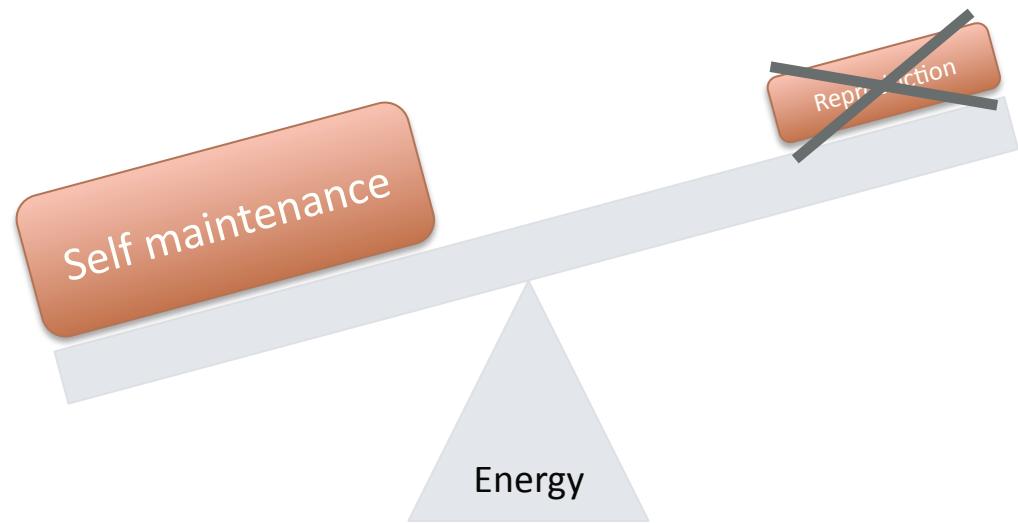


Background 1/2

- Limited resources

Life history trade-offs

Stearns 1992



Background 1/2

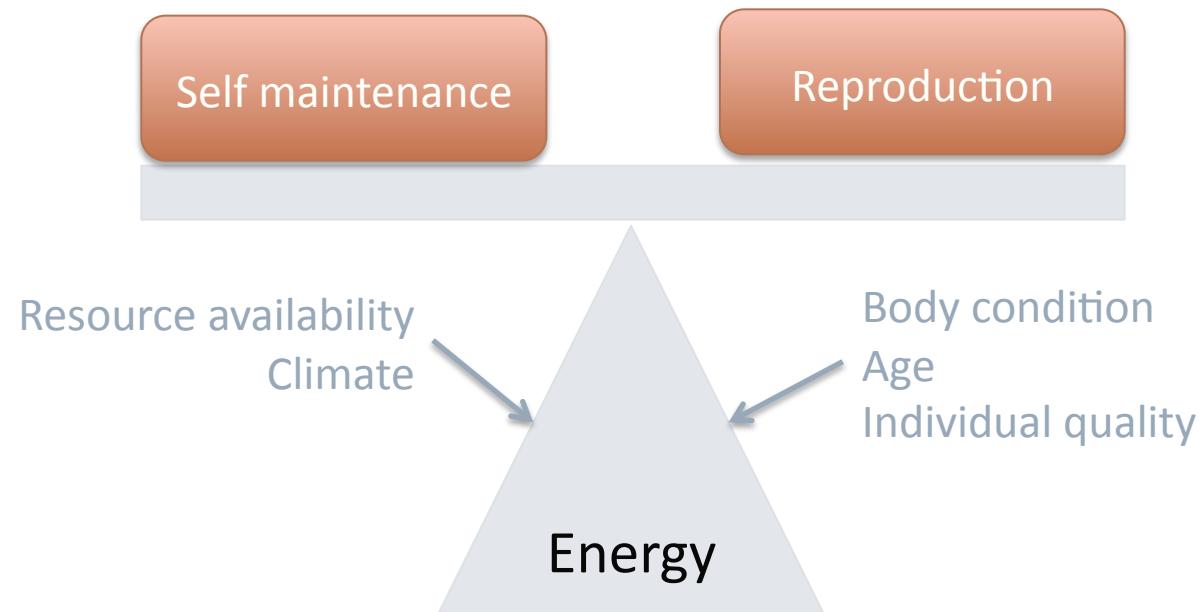
- Limited resources

Life history trade-offs

Stearns 1992

- Individual quality & environmental conditions

McNamara & Houston 1996



Background 1/2

- Limited resources

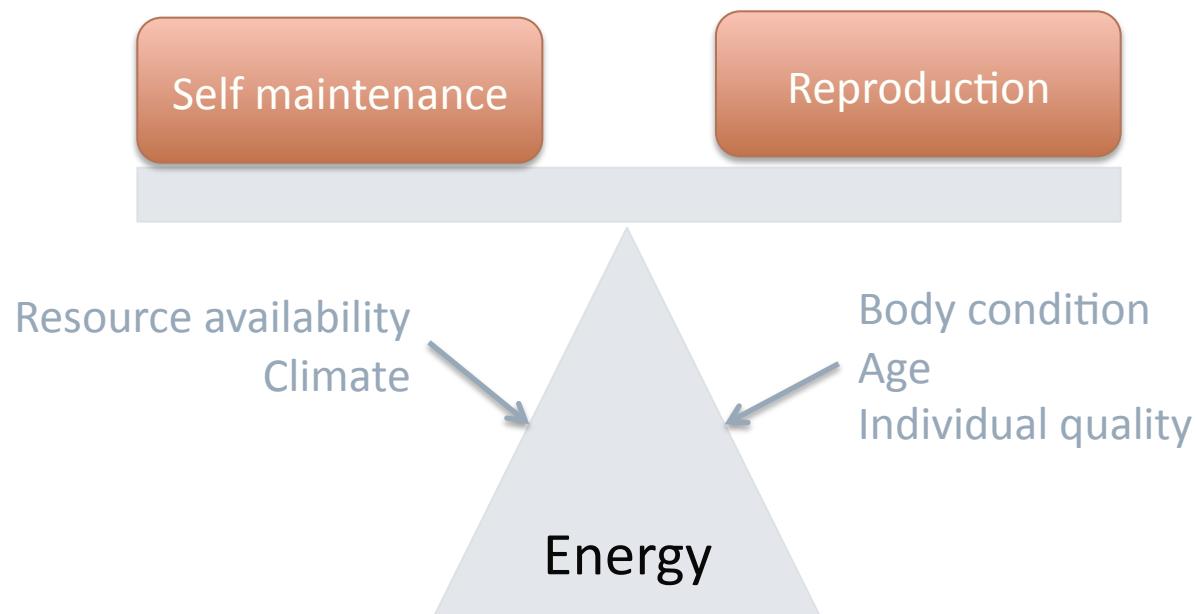
Life history trade-offs

Stearns 1992

- Individual quality & environmental conditions

McNamara & Houston 1996

Underlying mechanisms?



Background 1/2

- Limited resources

Life history trade-offs

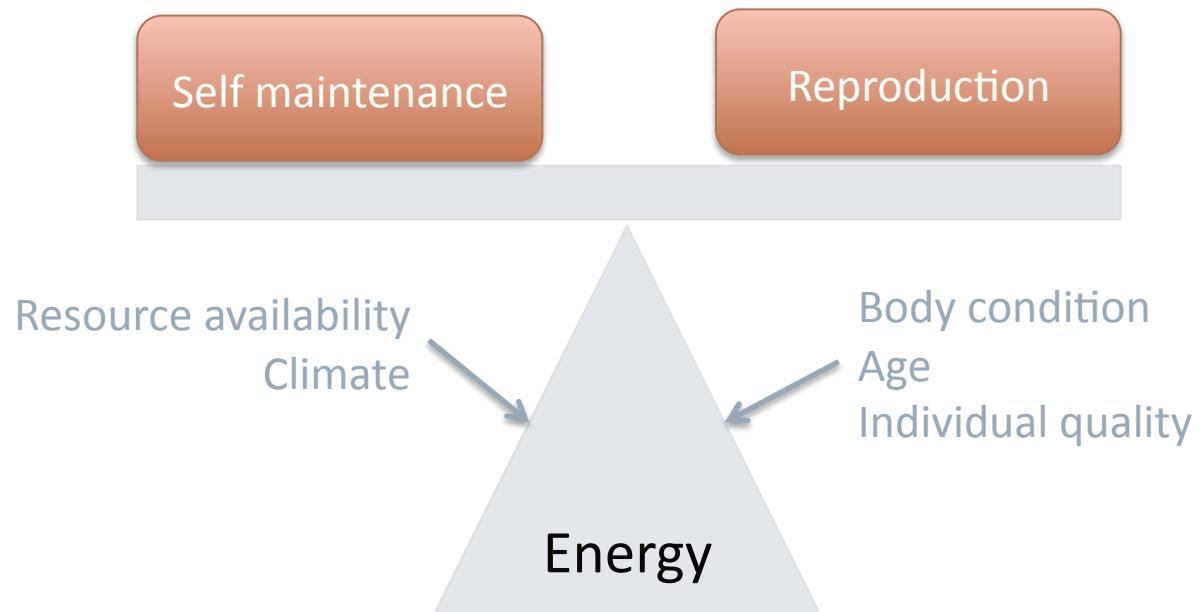
Stearns 1992

- Individual quality & environmental conditions

McNamara & Houston 1996

- Hormones as key regulators of life history trade offs

Underlying mechanisms?



Background 2/2

Corticosterone (CORT)

- Mediates resource allocation
- Secreted in response to a wide range of stressors
- Elevated baseline levels associated with energetic/environmental challenges

Landys et al. 2006

Background 2/2

Corticosterone (CORT)

- Mediates resource allocation
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Landys et al. 2006

Incubation

- Time & energy consumptive
- Bad incubation conditions can affect hatching success and chicks' body condition & growth

Metcalfe & Monaghan, 2001 ; DuRant *et al.* 2010



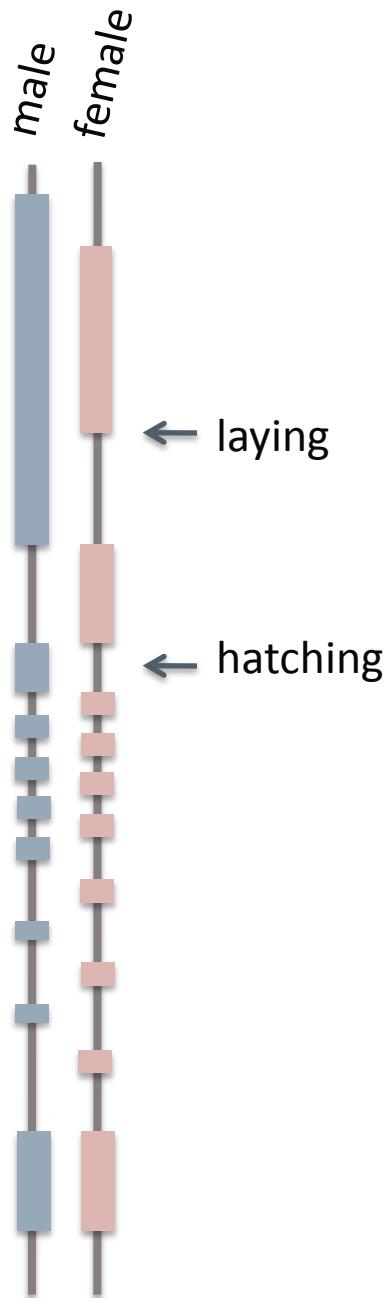
Objectives

Precise the implication of CORT in **breeding decisions & parental investment**

Experimental approach

Incubating male Adélie penguins





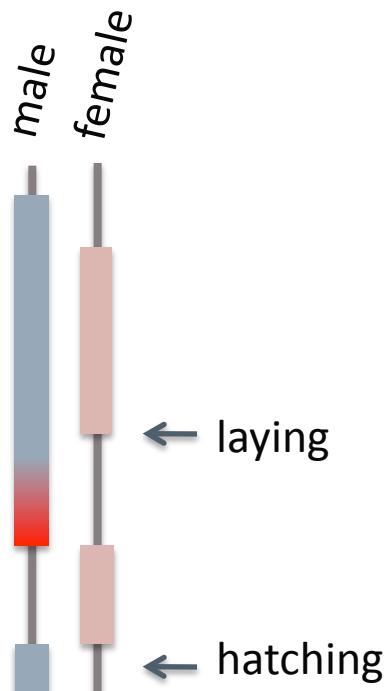
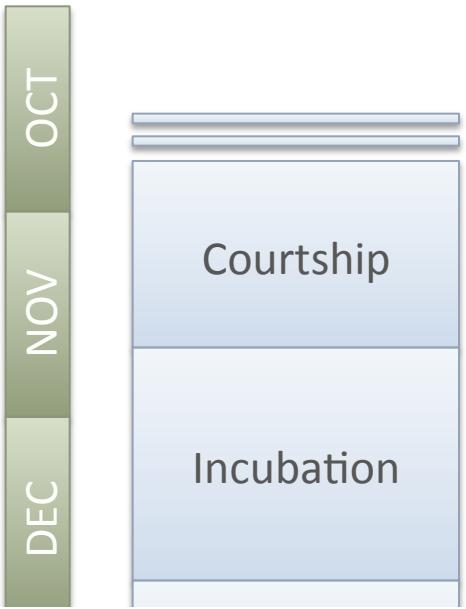
Why male Adélie penguins ?



| at sea

on land

Adélie penguin breeding cycle



Why **male** Adélie penguins ?



| at sea

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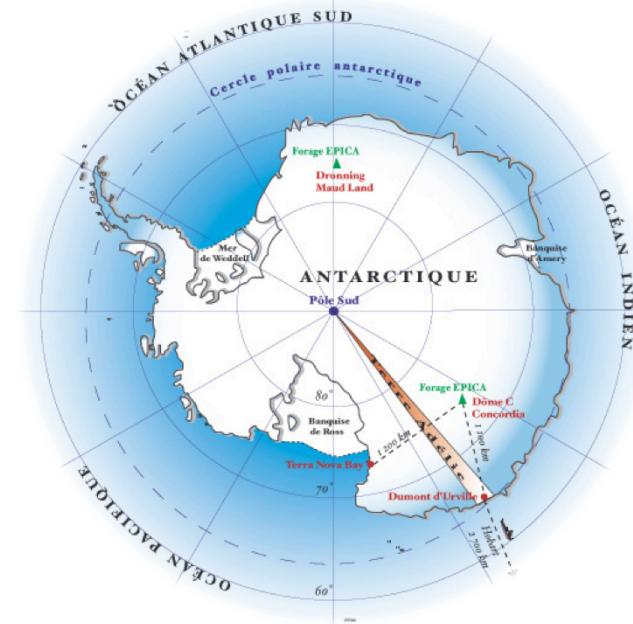
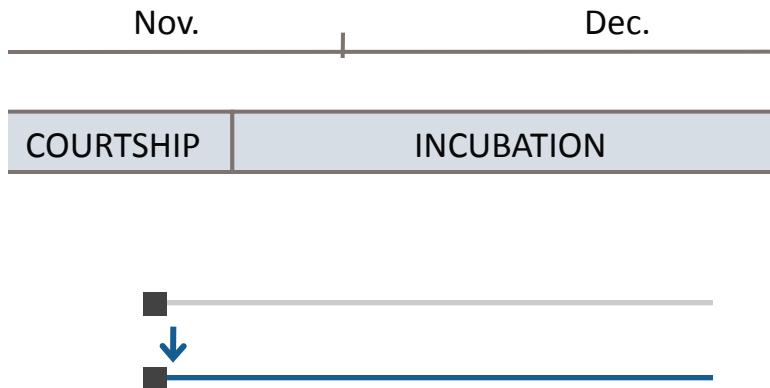
1. Elevated CORT & breeding success?

2. Elevated CORT & incubation behaviour?

- incubation temperatures
- egg turning

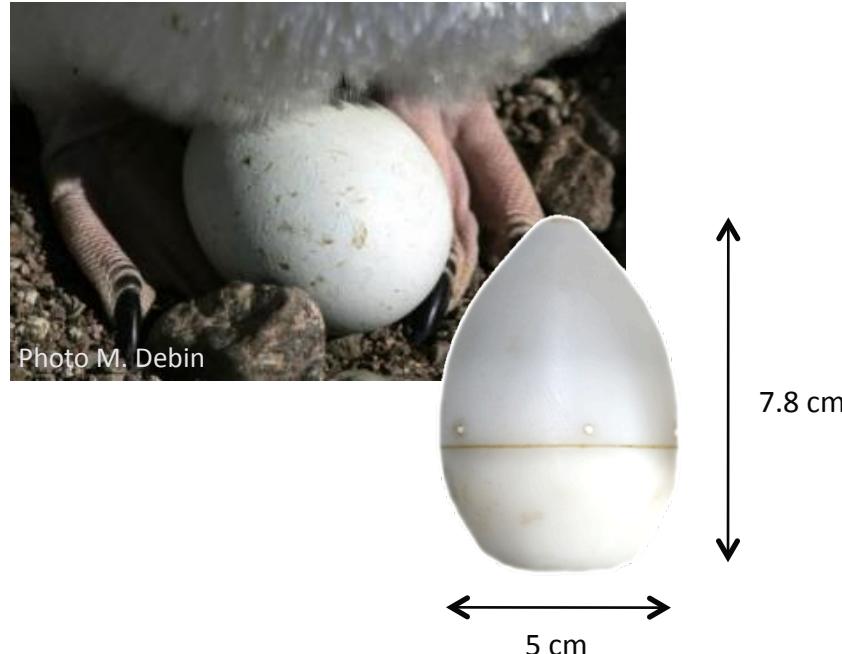
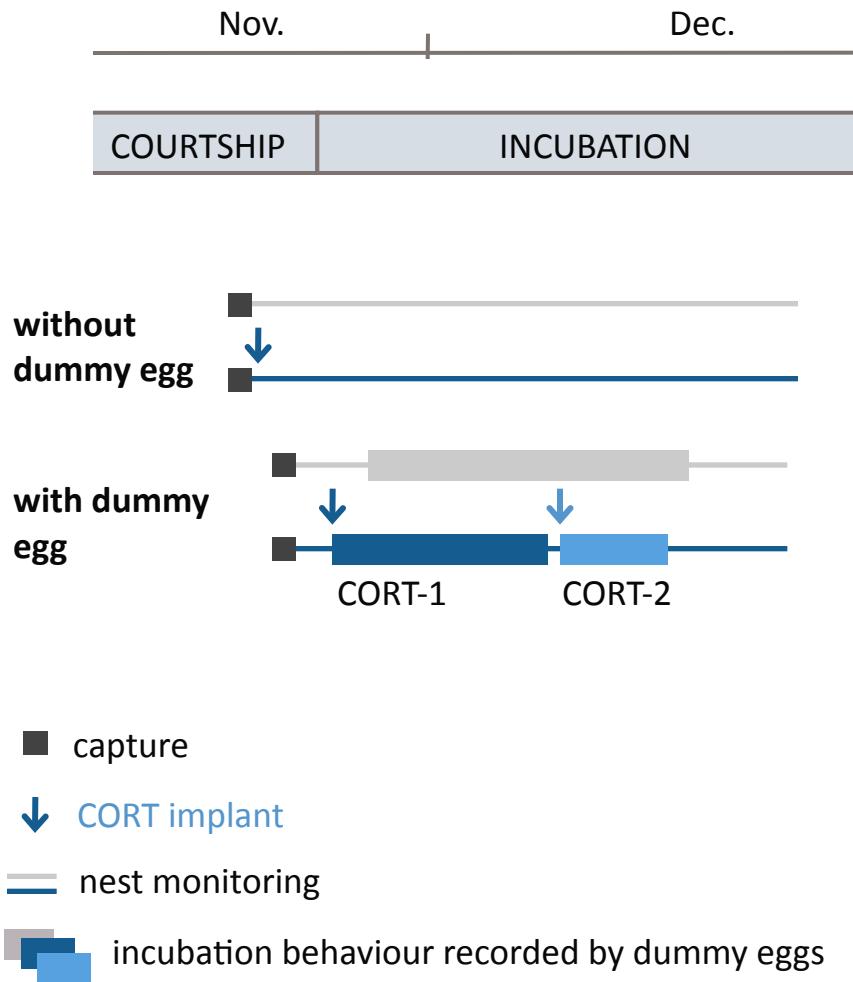
3. Elevated CORT, incubation behaviour & severe weather conditions?

Methods 1/2



	Sham	CORT
2007-2008	29	15
2008-2009	14	3
2009-2010	14	10

Methods 1/2



6 external + 1 internal temperature probes
2D accelerometer

	without dummy egg		with dummy egg	
	Sham	CORT	Sham	CORT
2007-2008	29	15	4	
2008-2009	14	3	5	9 (5+4)
2009-2010	14	10	6	

Methods 2/2

Data analysed with IGOR Pro & R

Macros written to calculate :

Mean temperature

Max temperature

Records above a threshold

Number of rotation events

...

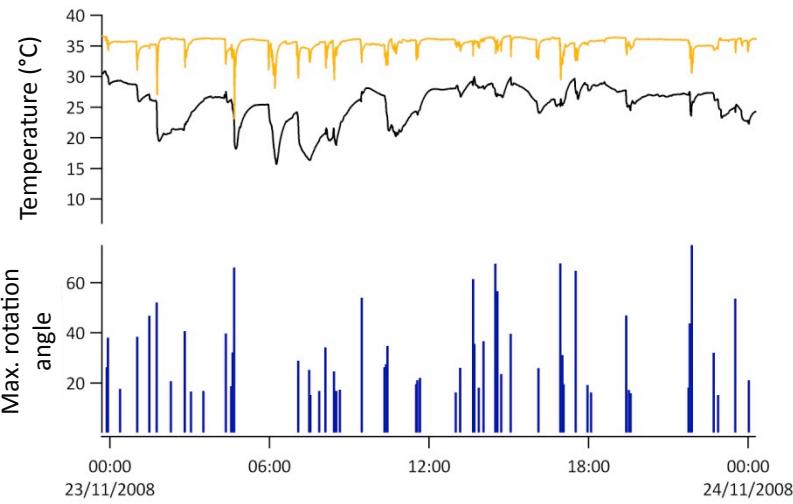
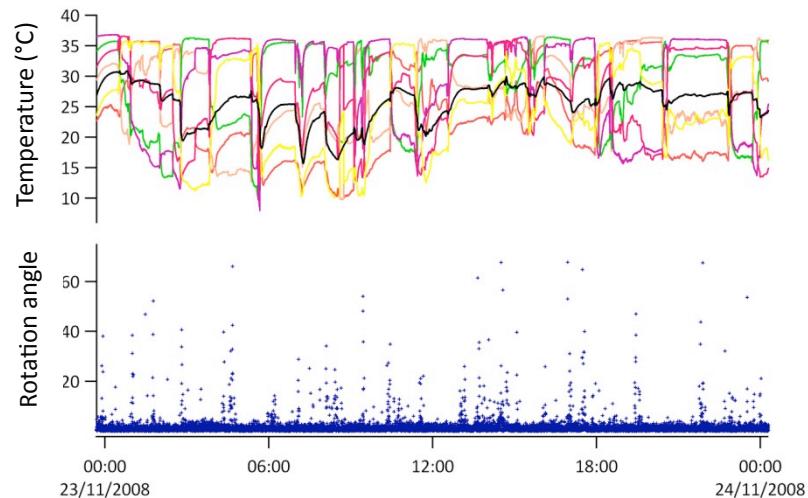
GLMMs

Number of records with $T_{int} \geq 30^\circ\text{C}$: 0

Number of records with $T_{max} \geq 30^\circ\text{C}$: 8615

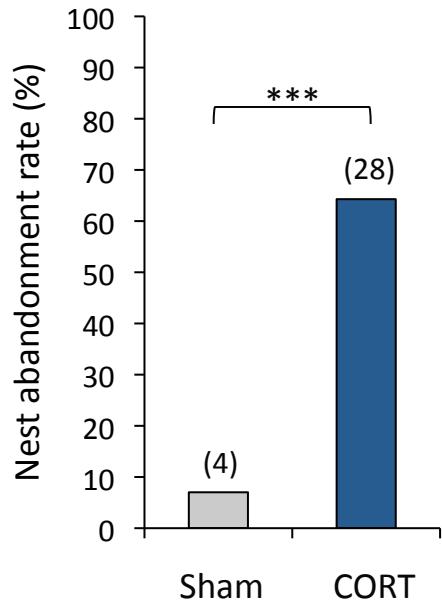
Total number of records : 8640

Number of egg turning events : 53



1. CORT & breeding success

1. CORT & breeding success



Fisher's exact test p<0,001



CORT : 14.7 ± 0.9 days after treatment

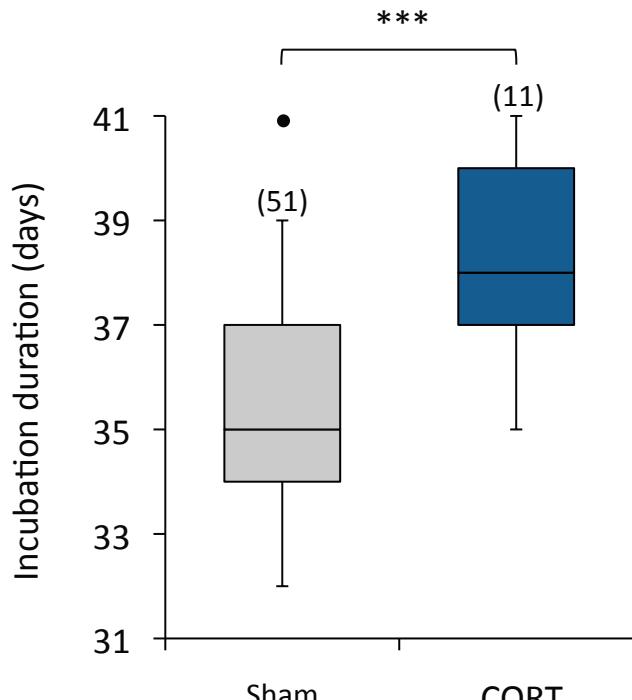
Sham : 21.5 ± 1.8

Early nest desertion

↙ parental investment

1. CORT & breeding success

When no nest desertion :

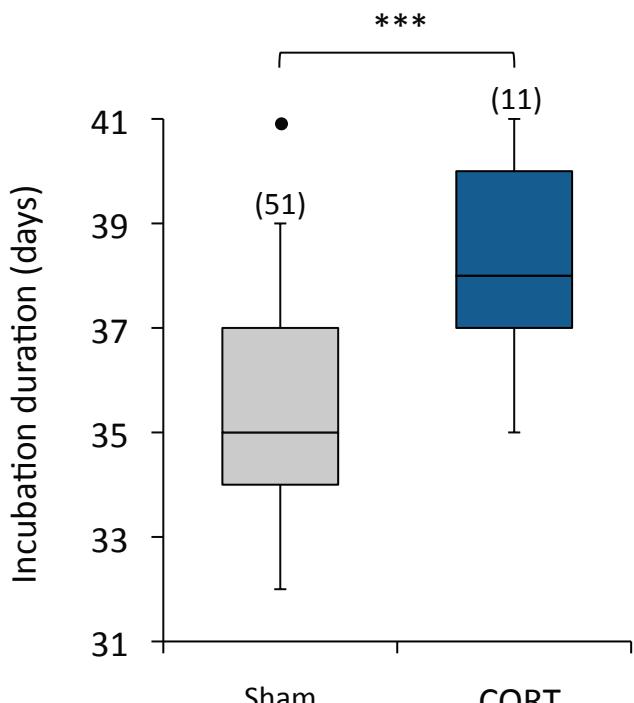


Wilcoxon p<0,001

Increased incubation duration

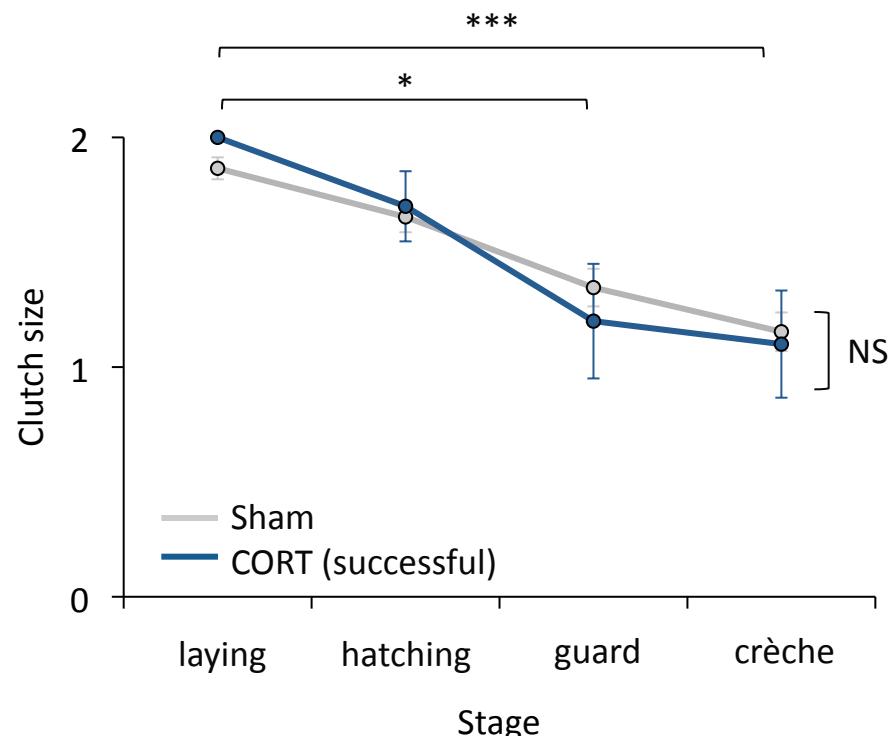
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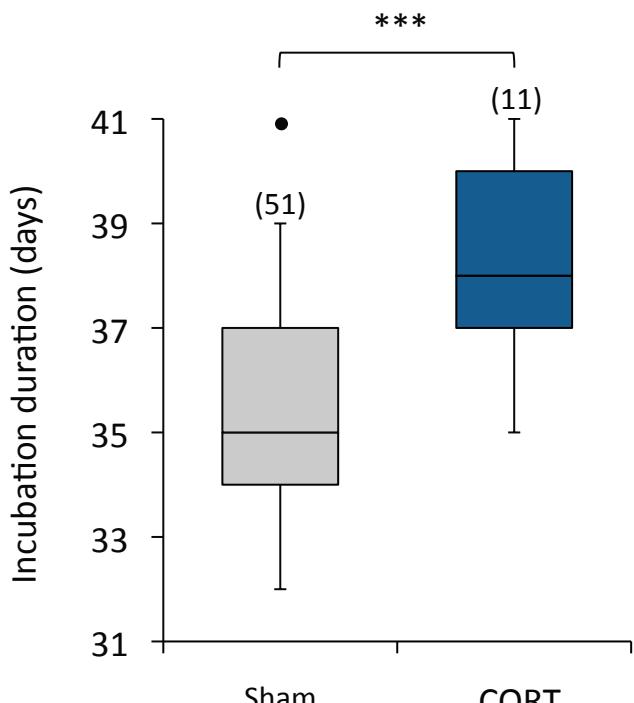


GLMM, Poisson. n=58, 232 observations

Similar breeding success

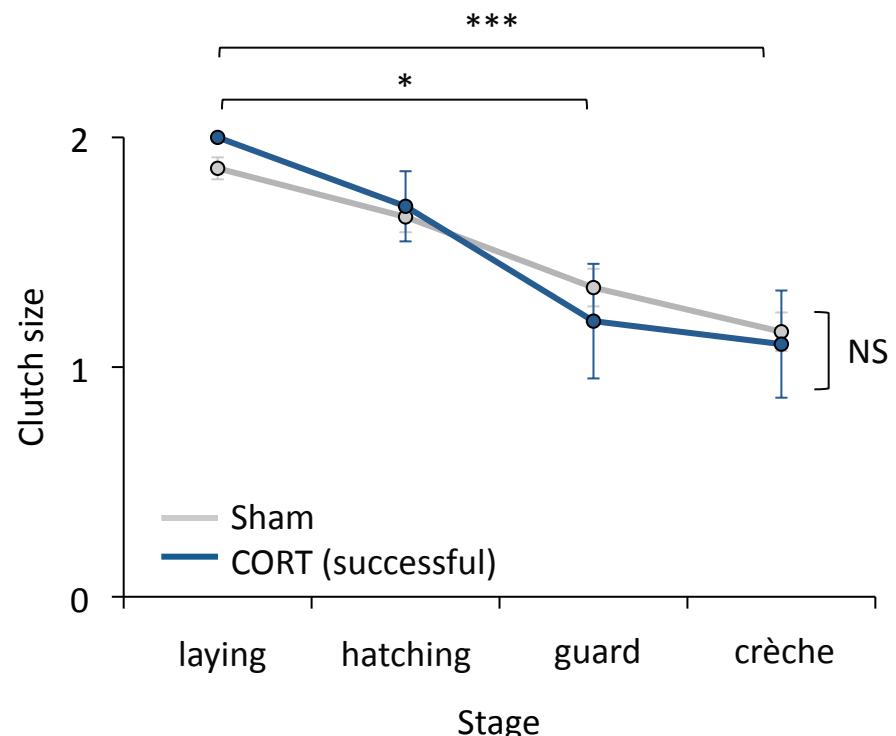
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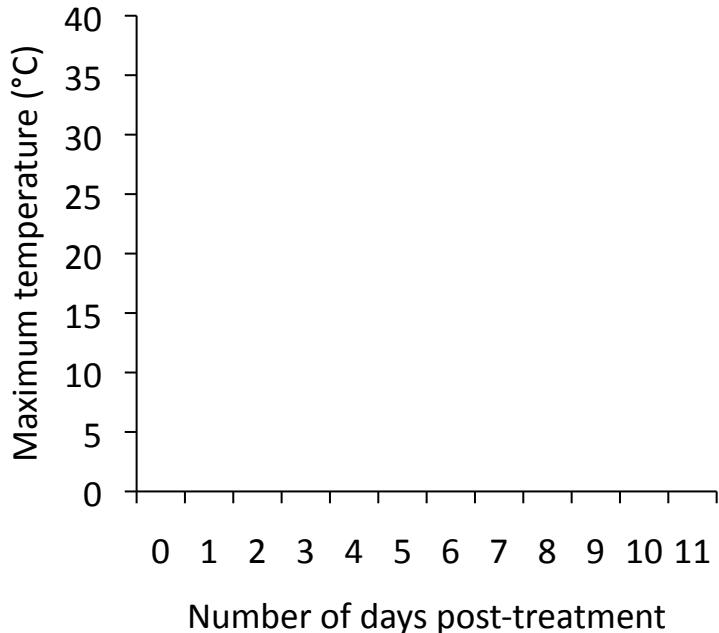


GLMM, Poisson. n=58, 232 observations

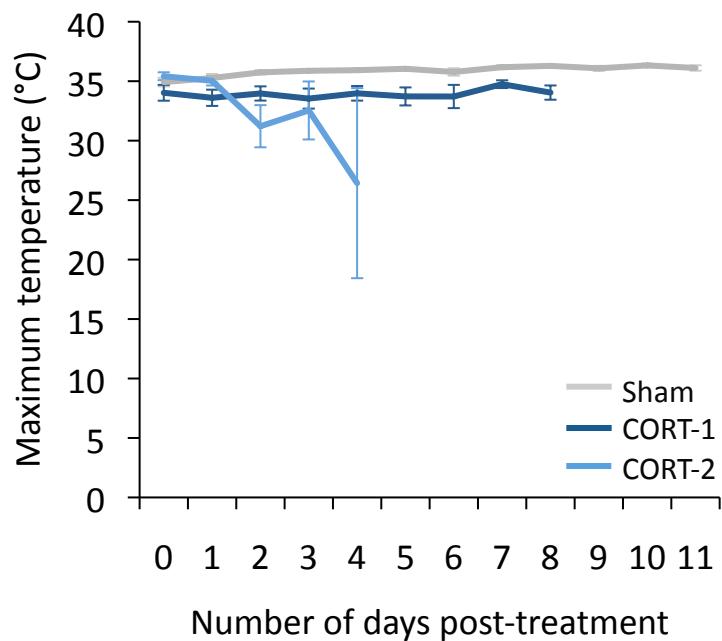
Similar breeding success

Different incubation behaviour ?

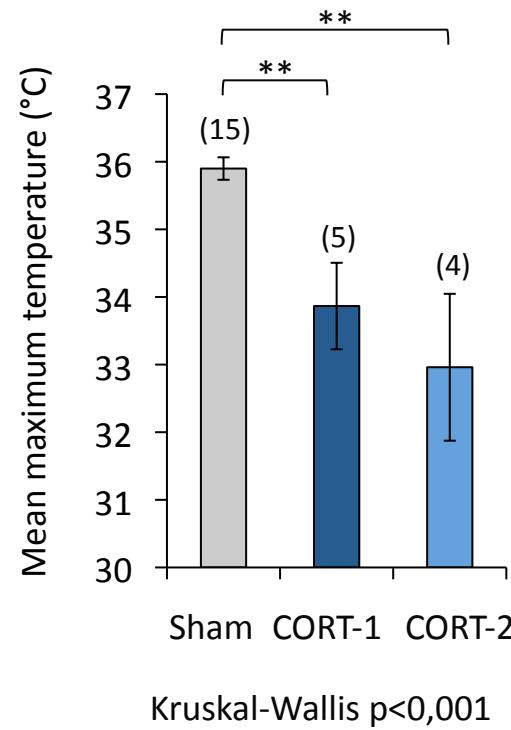
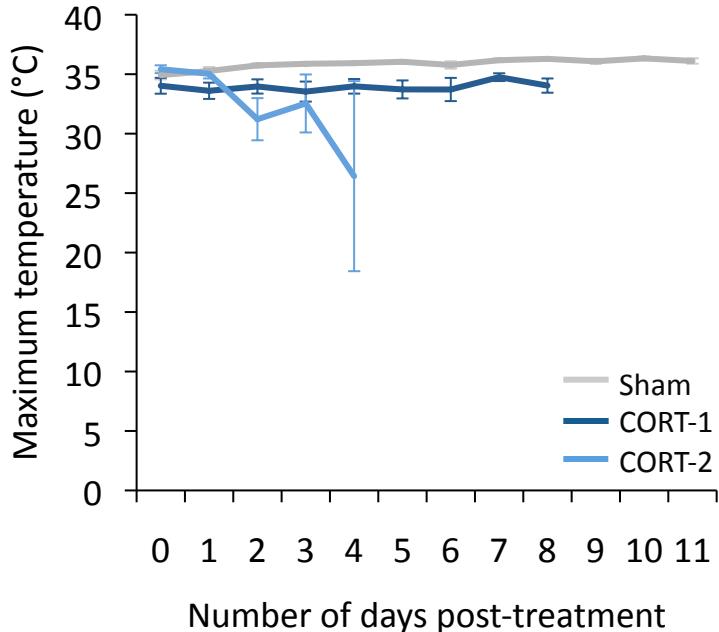
2. CORT & incubation behaviour



2. CORT & incubation behaviour

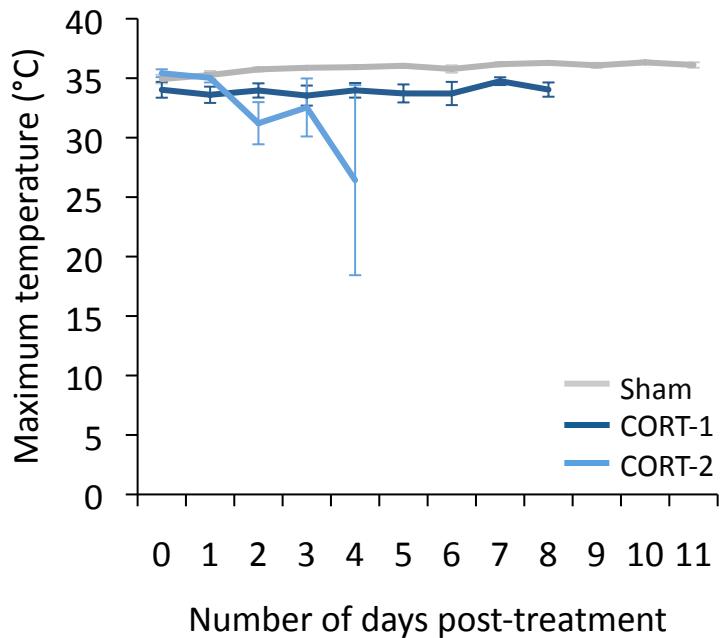


2. CORT & incubation behaviour



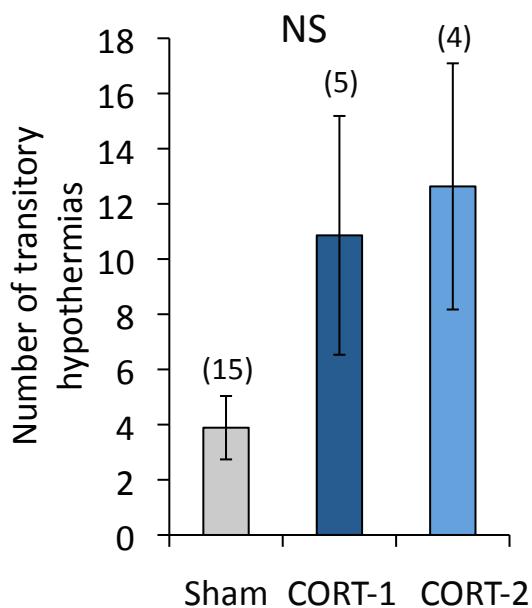
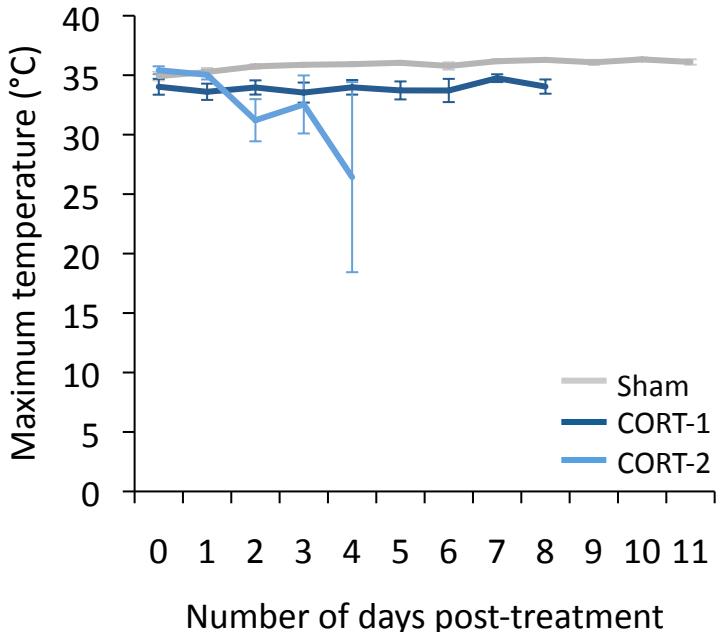
Lower incubation temperatures in CORT-treated birds

2. CORT & incubation behaviour

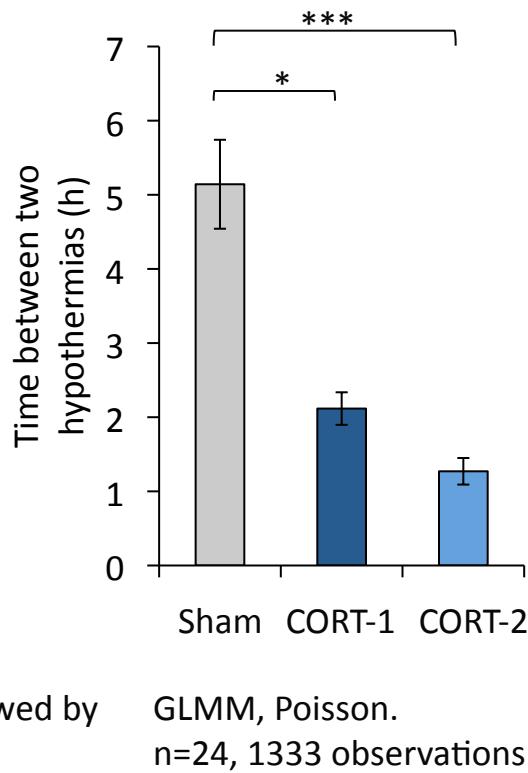


Lower incubation temperatures in CORT-treated birds

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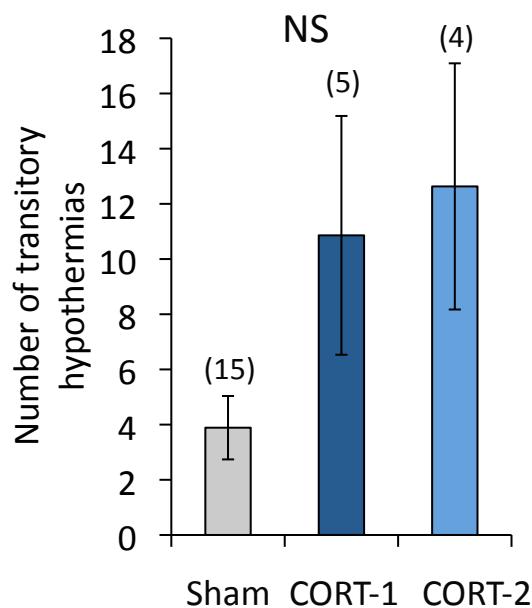
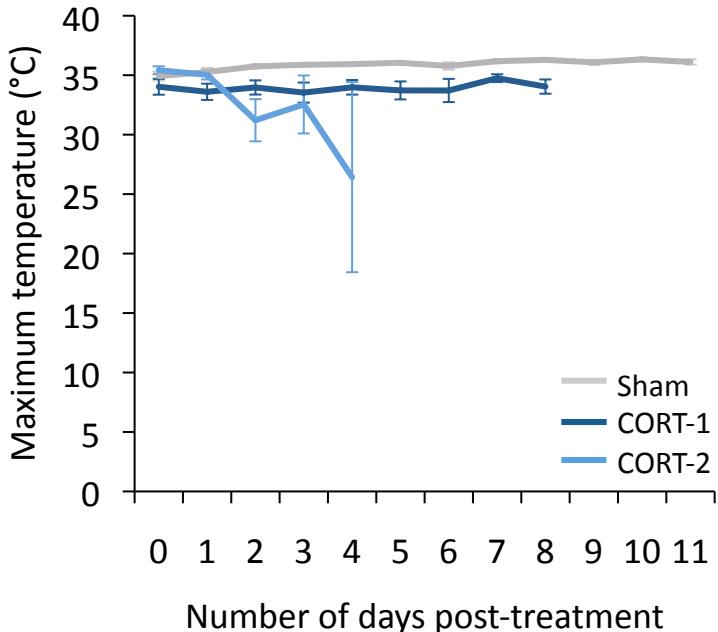
Kruskal-Wallis p=0,021 followed by
multiple comparisons



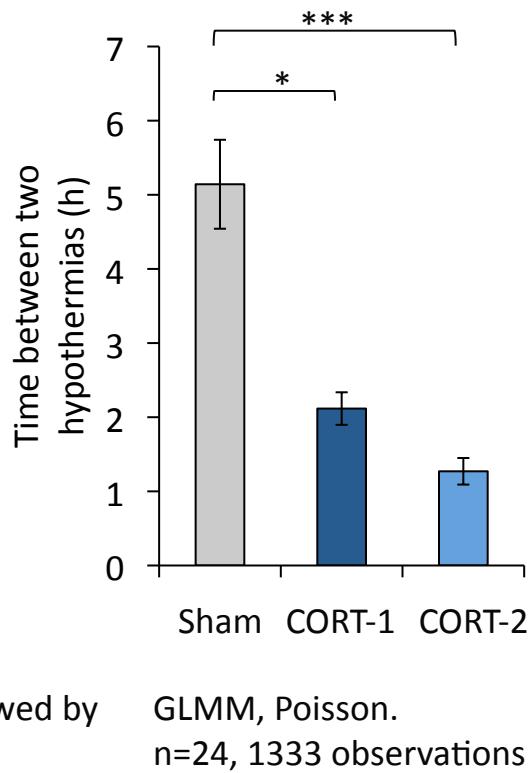
GLMM, Poisson.
n=24, 1333 observations

**Lower incubation temperatures in CORT-treated birds
Through more frequent hypothermias (Tmax <30°C)**

2. CORT & incubation behaviour



Kruskal-Wallis p=0,021 followed by
multiple comparisons

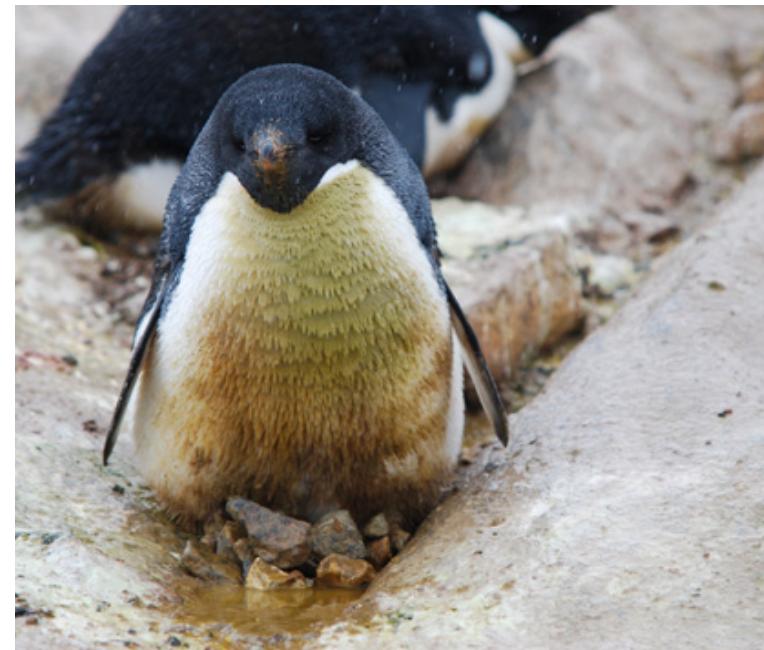


GLMM, Poisson.
n=24, 1333 observations

Lower incubation temperatures in CORT-treated birds
Through more frequent hypothermias (Tmax <30°C)
Similar egg turning rates (data not shown)

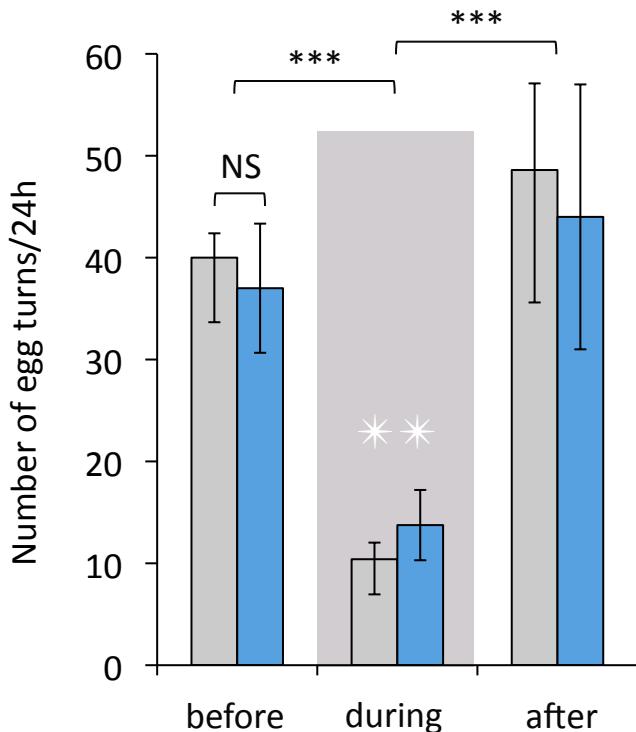
3. CORT, incubation & severe weather conditions

How do penguins incubate during/after blizzard?



3. CORT, incubation & severe weather conditions

How do penguins incubate during/after blizzard?

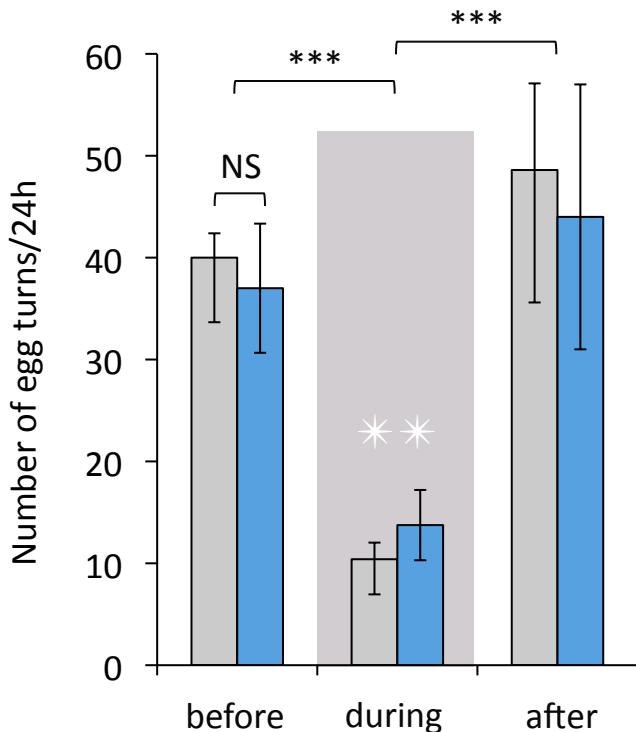


GLMM, Poisson; n=9, 25 observations ; treatment
p=0,685, period p<0,001, treatment:period p≥0,489

Weather affects egg turning behaviour

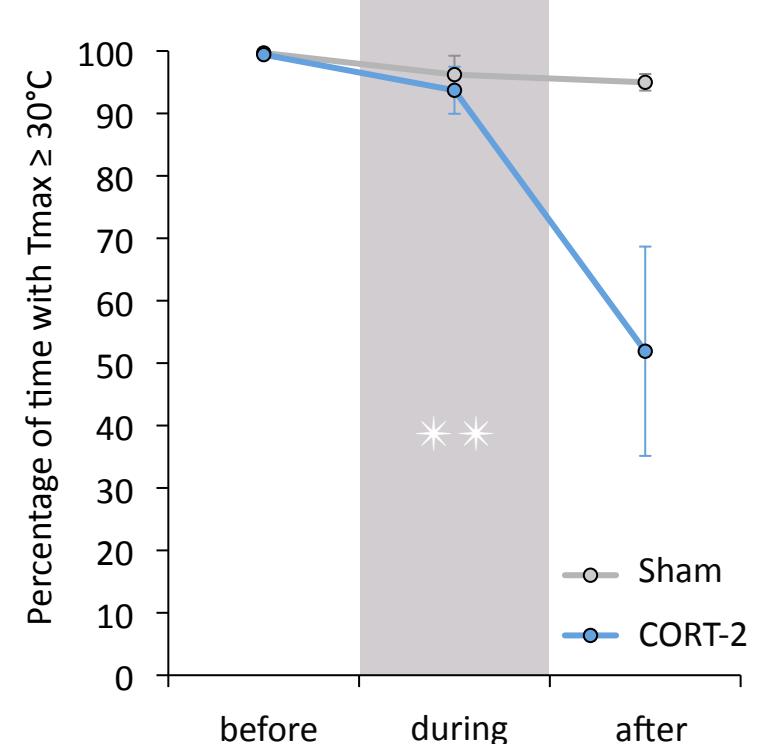
3. CORT, incubation & severe weather conditions

How do penguins incubate during/after blizzard?



GLMM, Poisson; n=9, 25 observations ; treatment
p=0,685, period p<0,001, treatment:period p≥0,489

Weather affects egg turning behaviour



GLMM, binomial ; n=9, 27 observations ; treatment
p=0,002, period p<0,001, treatment:period p<0,05

Lower incubation temperatures in CORT-treated birds

Conclusion & perspectives

Conclusion & perspectives

Reduced parental investment in CORT-treated birds :

- Early nest abandonment
- Decreased incubation temperatures,
especially during severe weather conditions

Conclusion & perspectives

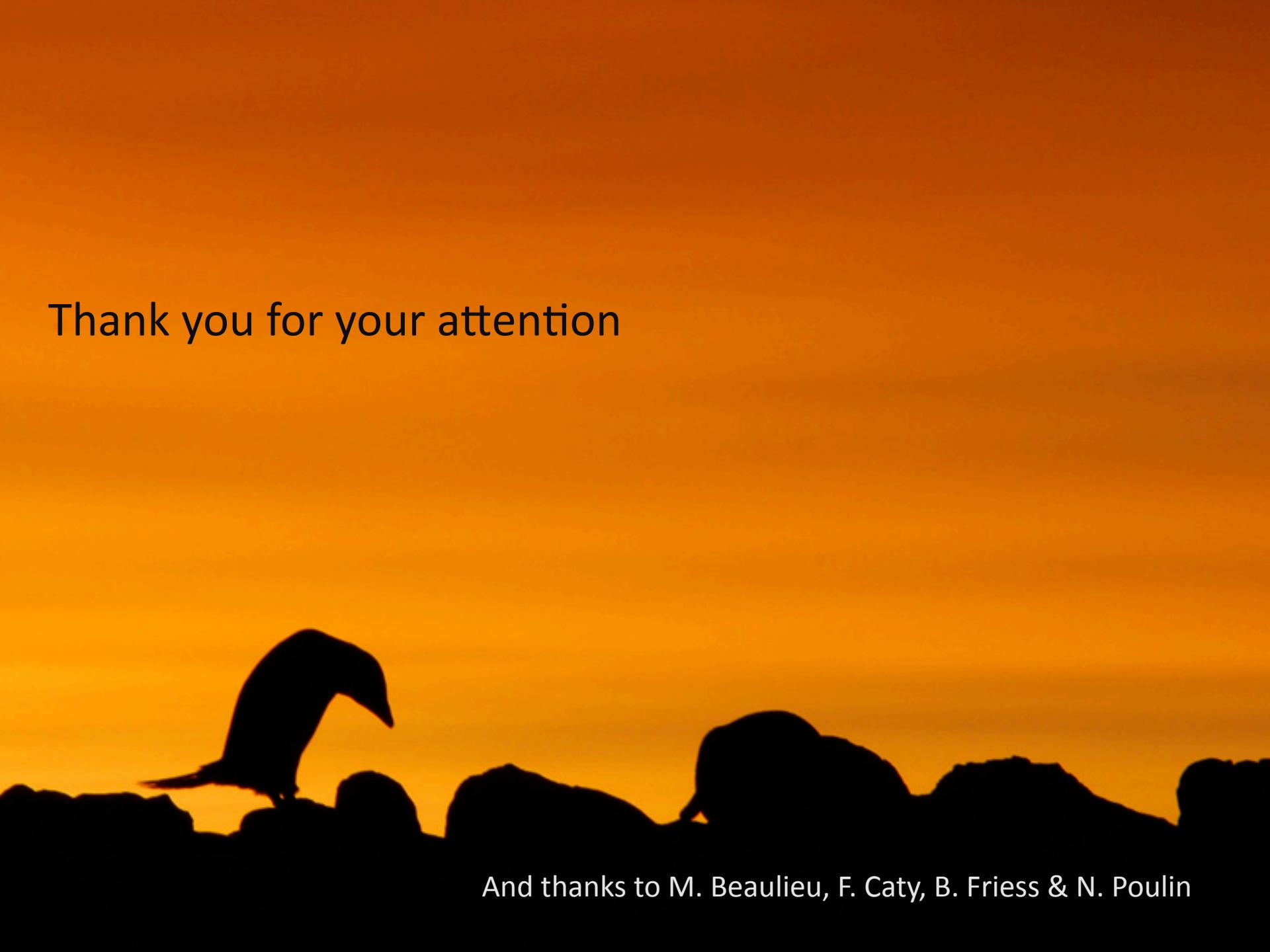
Reduced parental investment in CORT-treated birds :

- Early nest abandonment
- Decreased incubation temperatures,
especially during severe weather conditions

Precise the effects of environmental conditions on :

- incubation behaviour & embryonic development
- hatching date & chicks' quality



A silhouette of a penguin colony against a vibrant orange sunset sky. The penguins are in various poses, some standing upright, some huddled together, and one on the far left is captured mid-jump. The dark silhouettes of the penguins and the horizon line provide a stark contrast to the warm, glowing background.

Thank you for your attention

And thanks to M. Beaulieu, F. Caty, B. Friess & N. Poulin