The genomic & phenotypic consequences of breeding status in social mole-rats

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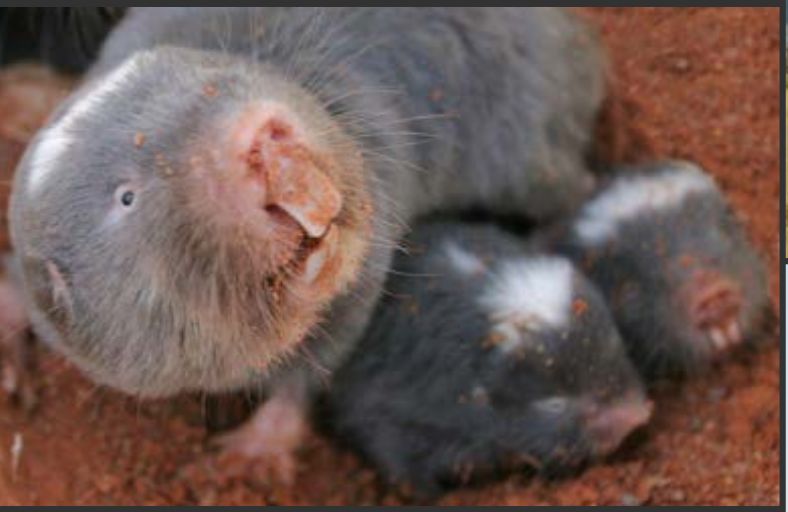
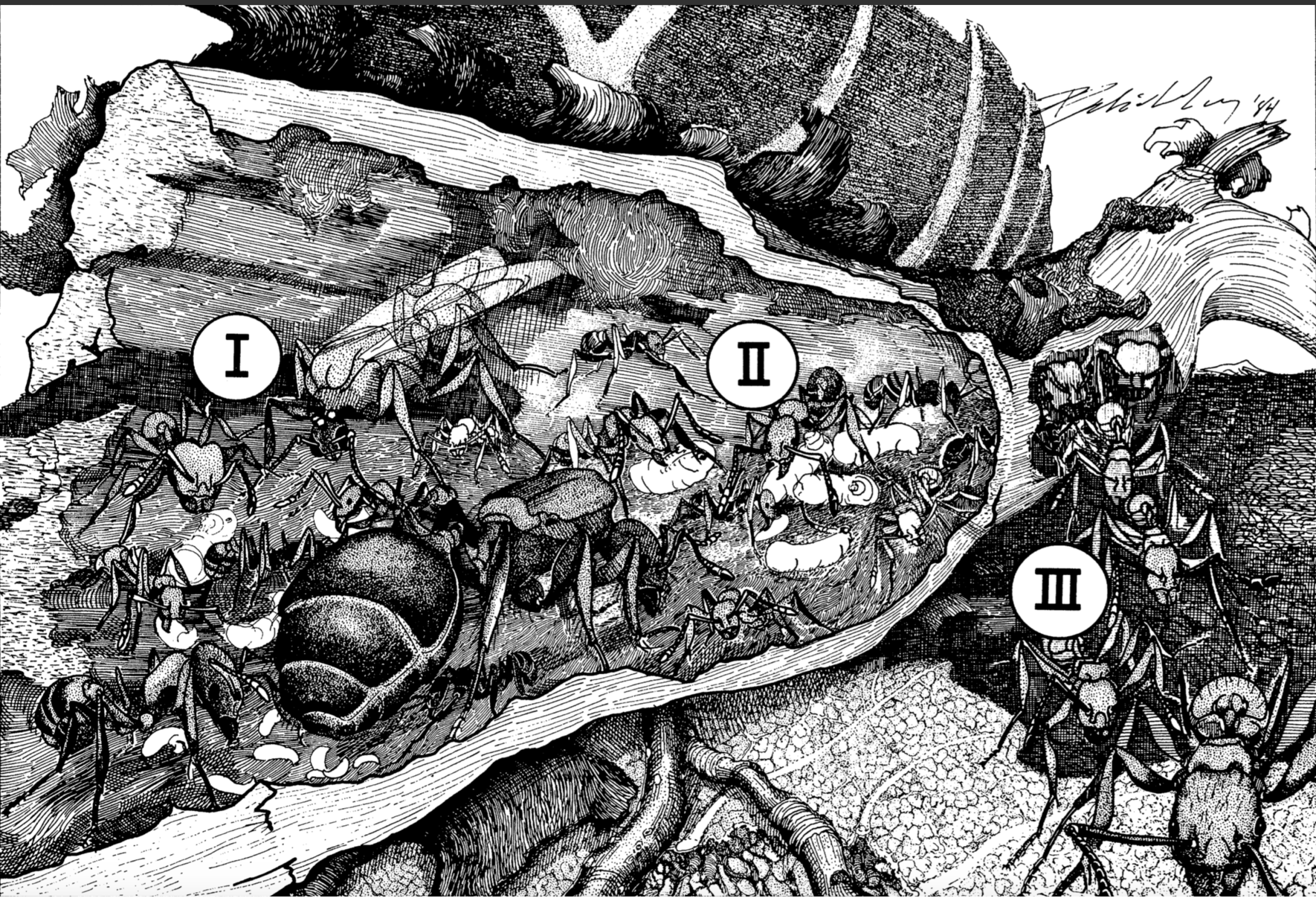
Zoo New England & Broad Institute



Wilson, 1985



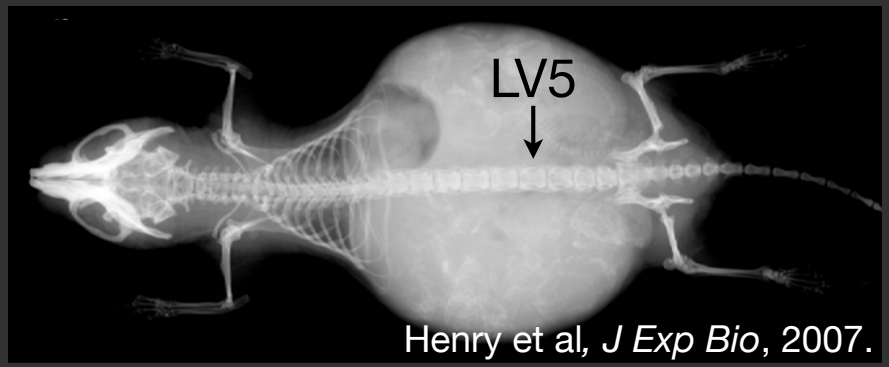
Naked mole-rat
Heterocephalus glaber

Damaraland mole-rat
Fukomys damarensis

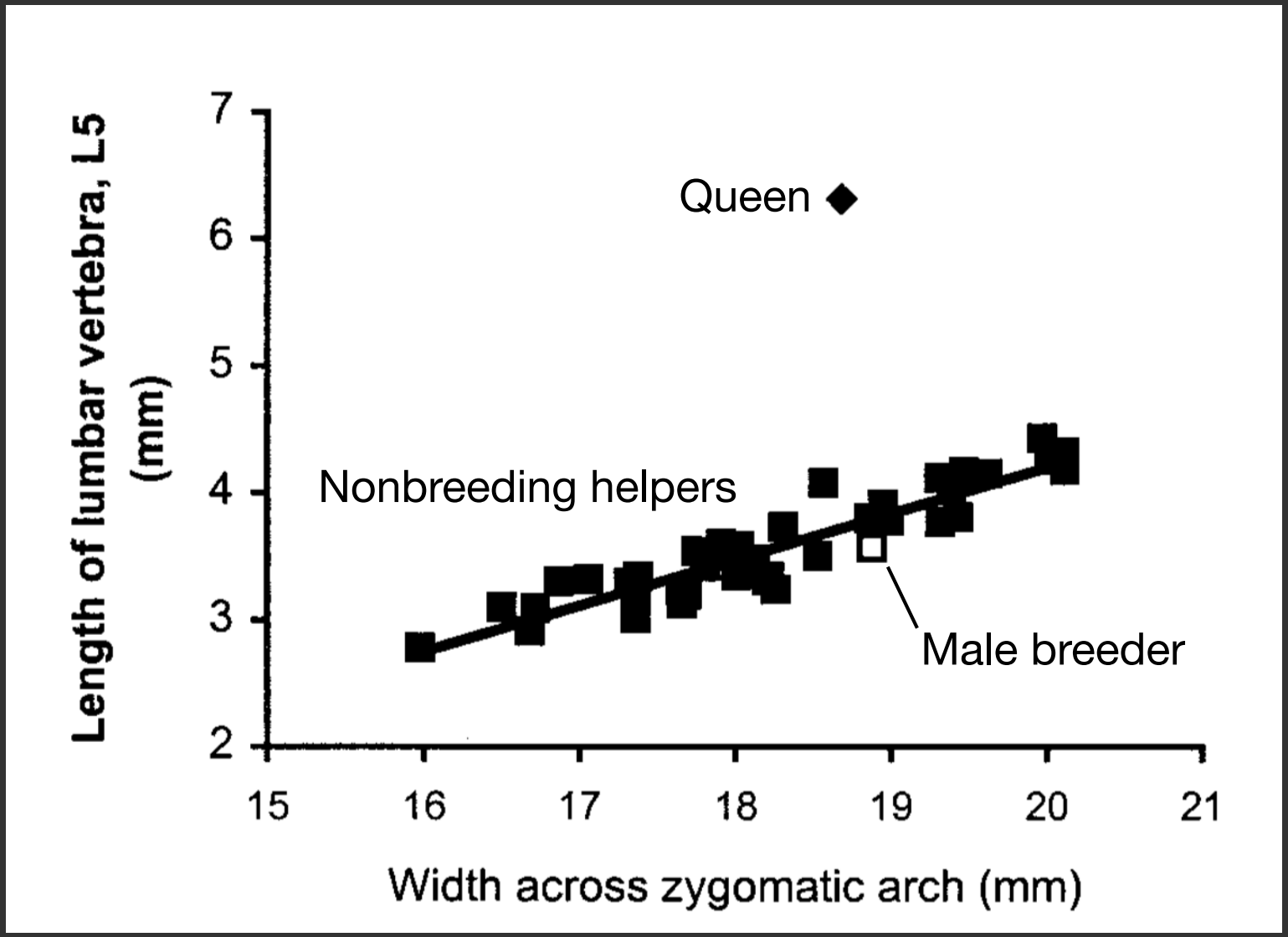
EO Wilson's three criteria for eusociality:

1. Reproductive division of labor
2. Overlap of ≥ two generations contributing to colony labor
3. Colony members cooperate in caring for young

Wilson, 1971.
Faulkes & Bennett, 2015.



Henry et al, *J Exp Bio*, 2007.



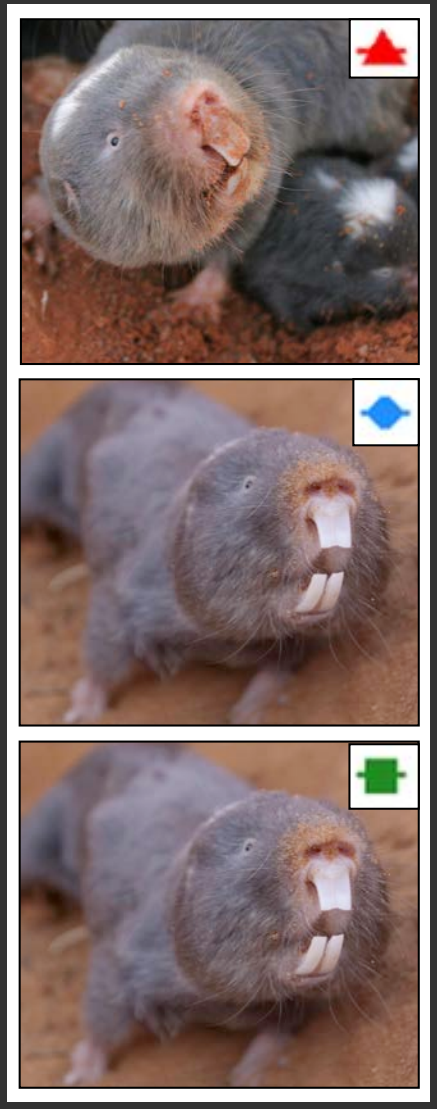
O'Riain et al, *PNAS*, 2000.

Adult full sisters

Queen

Non-breeding helper

Non-breeding solitaire



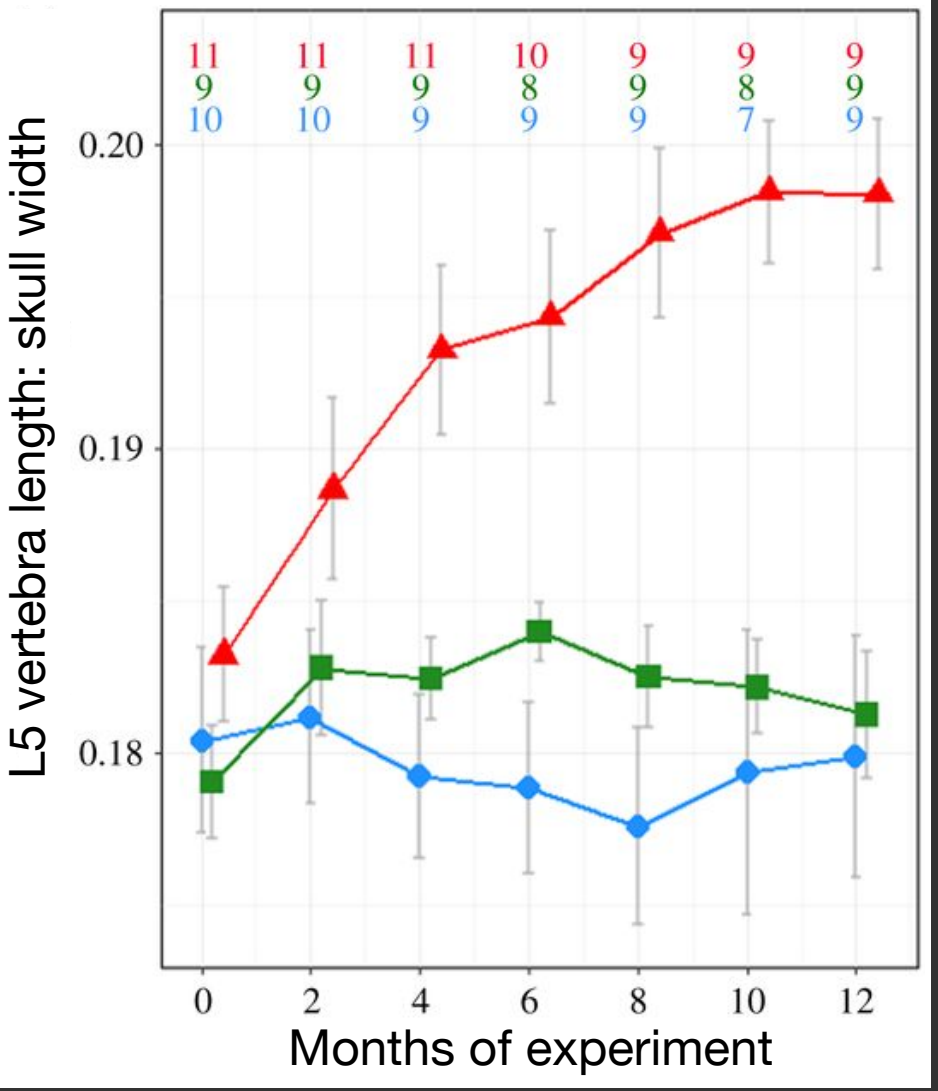
Thorley et al, *Proc. R. Soc. B*, 2018.

Adult full sisters

Queen

Non-breeding helper

Non-breeding solitaire



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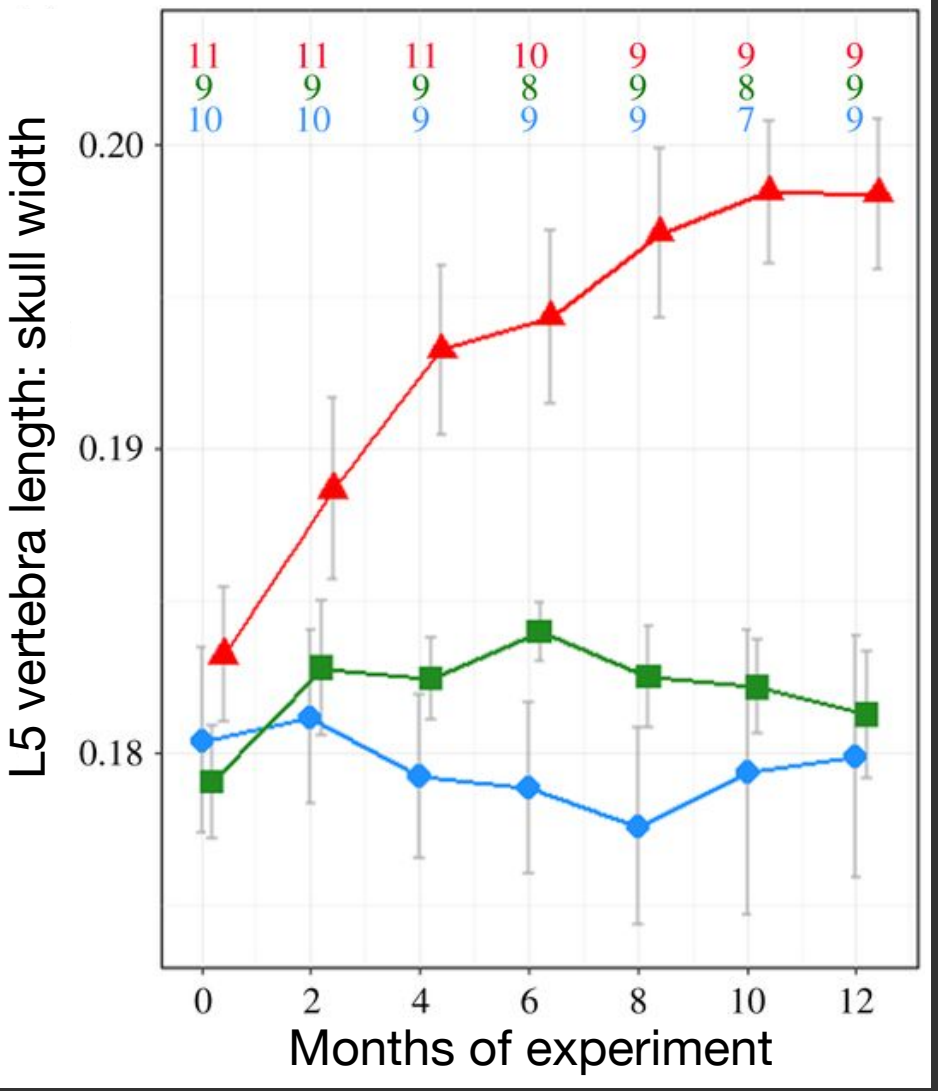
Adult full sisters

Queen

Non-breeding helper

Non-breeding solitaire



Thorley et al, *Proc. R. Soc. B*, 2018.

Questions

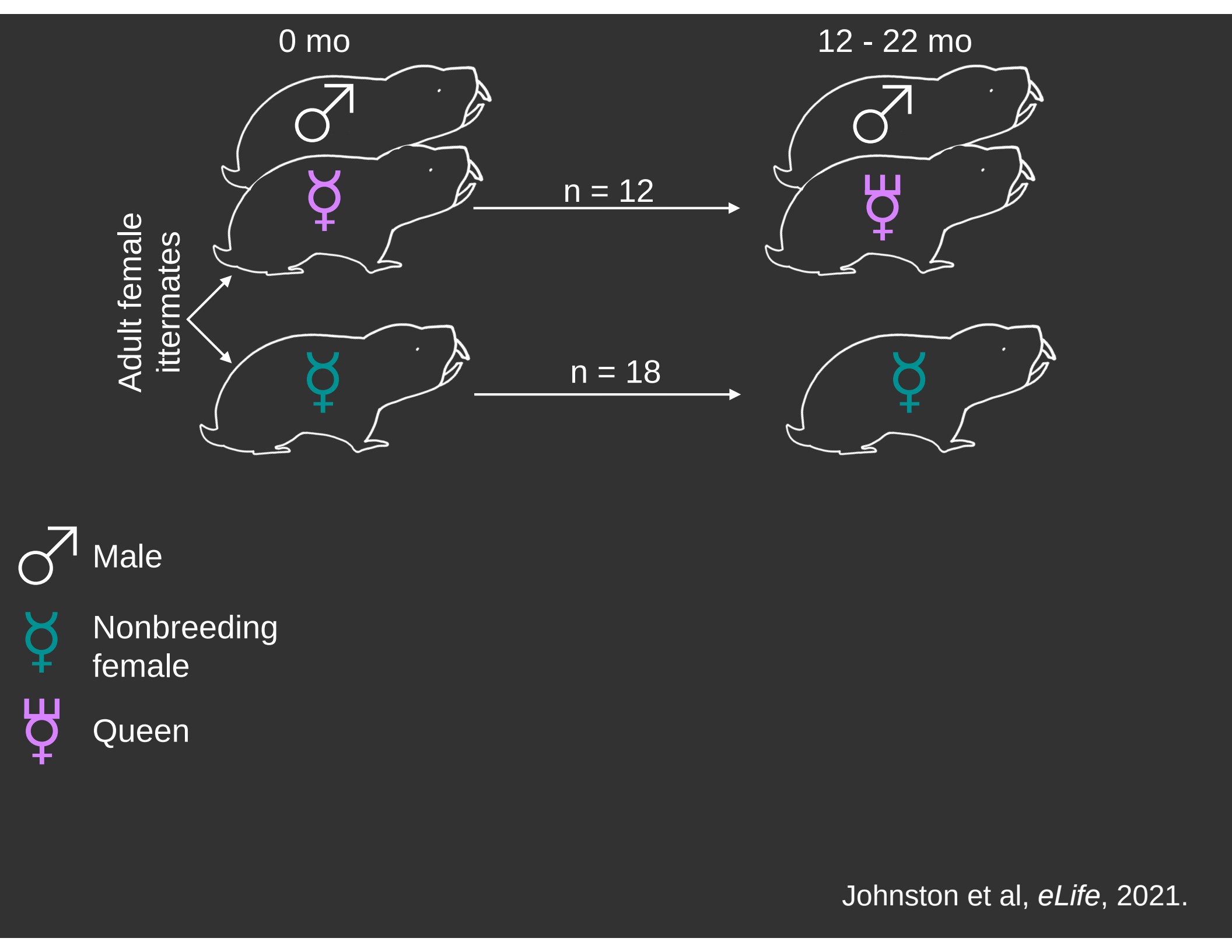
1. What are the gene regulatory changes that support skeletal remodeling?

2. Does queen status extend to other parts of the skeleton?

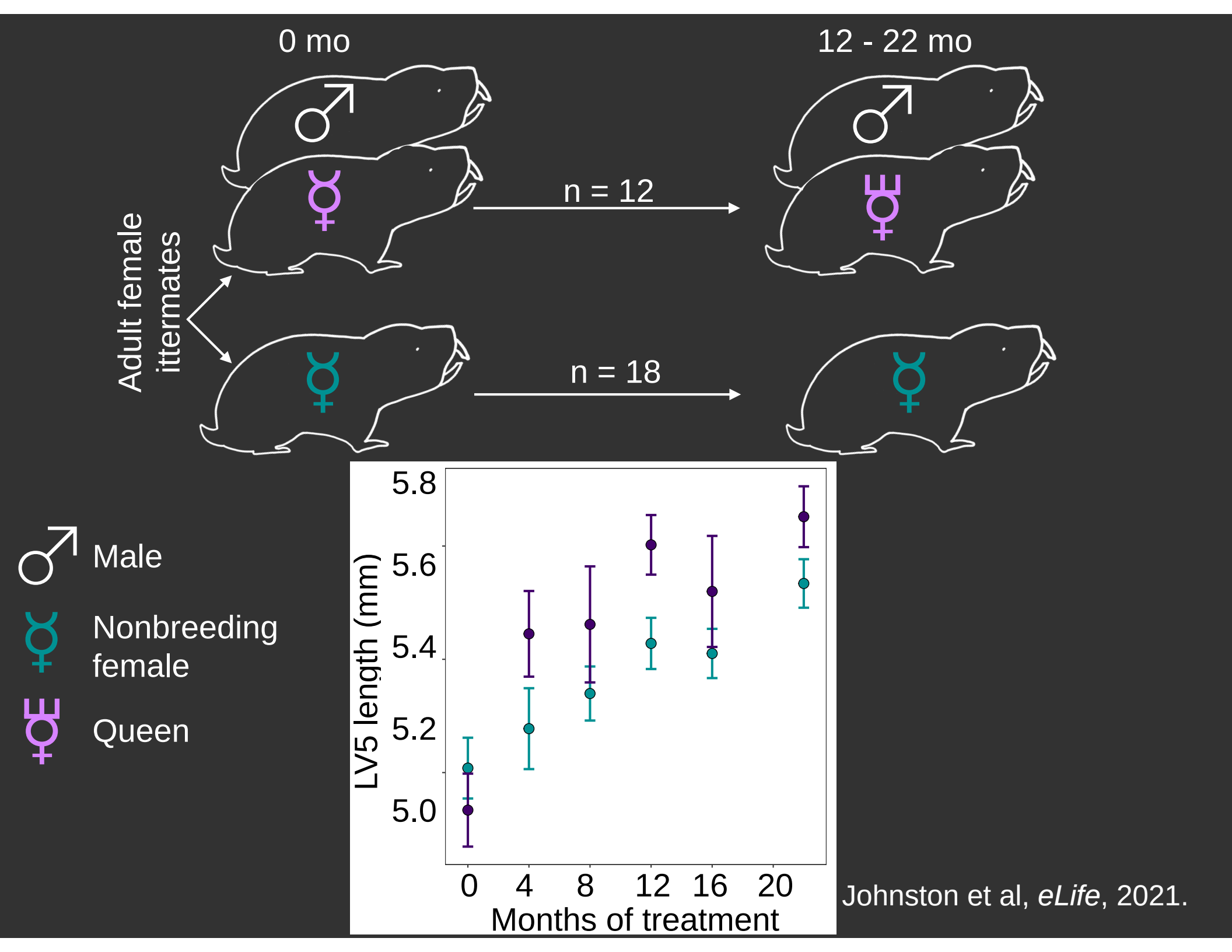
3. Do changes reflect consequences of intensive reproductive investment that has evolved in this social system?

Photo credit: Kyle Finn

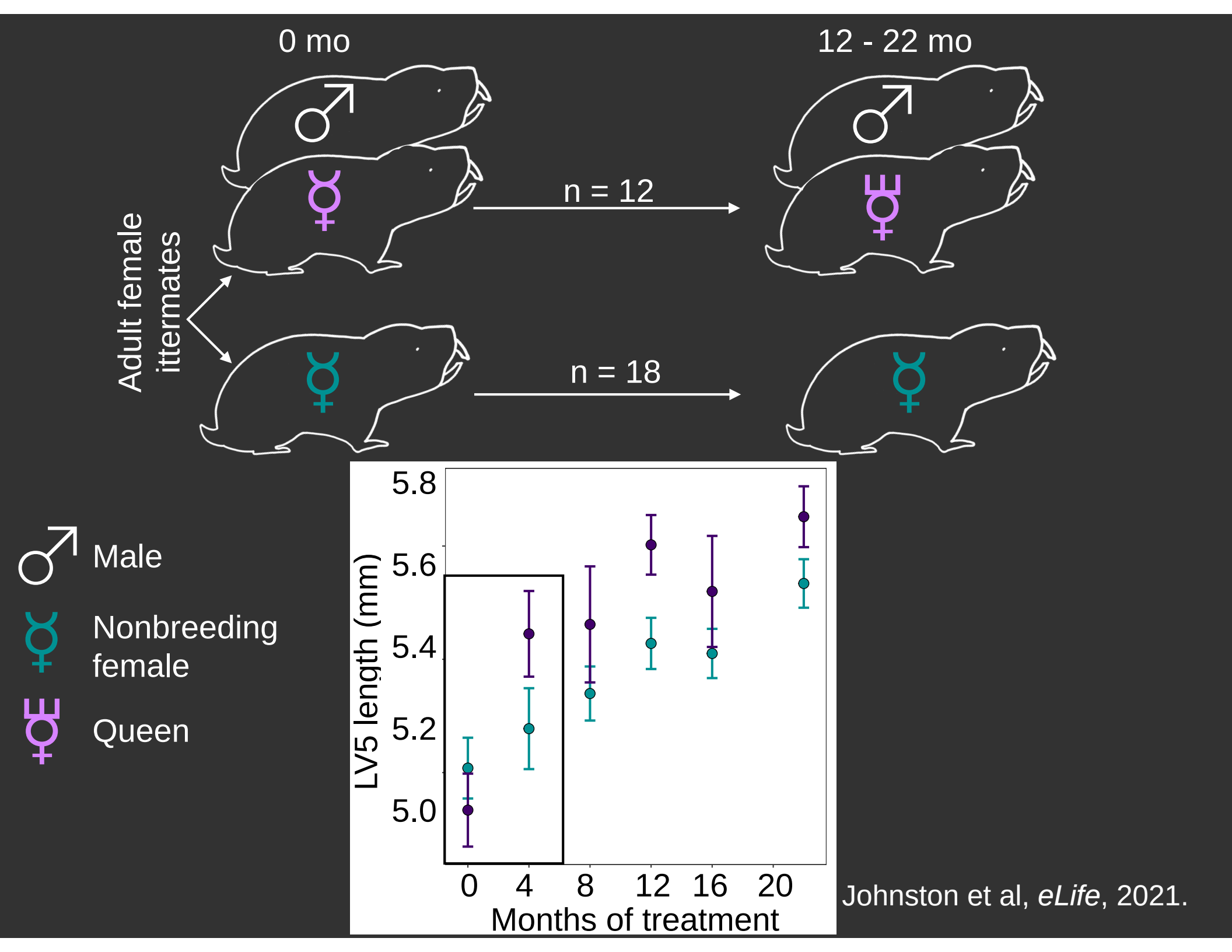
Kalahari Research Centre



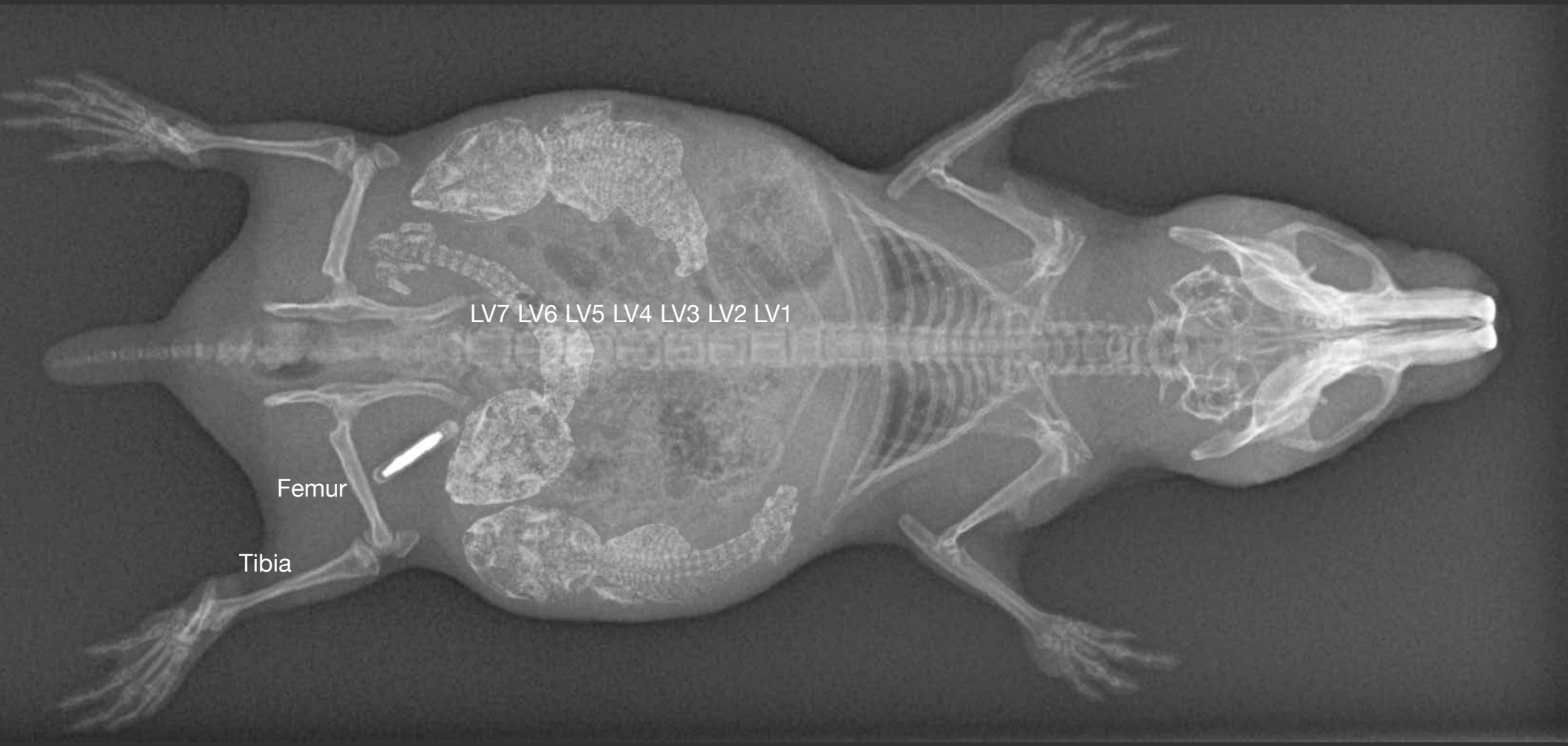
Johnston et al, *eLife*, 2021.

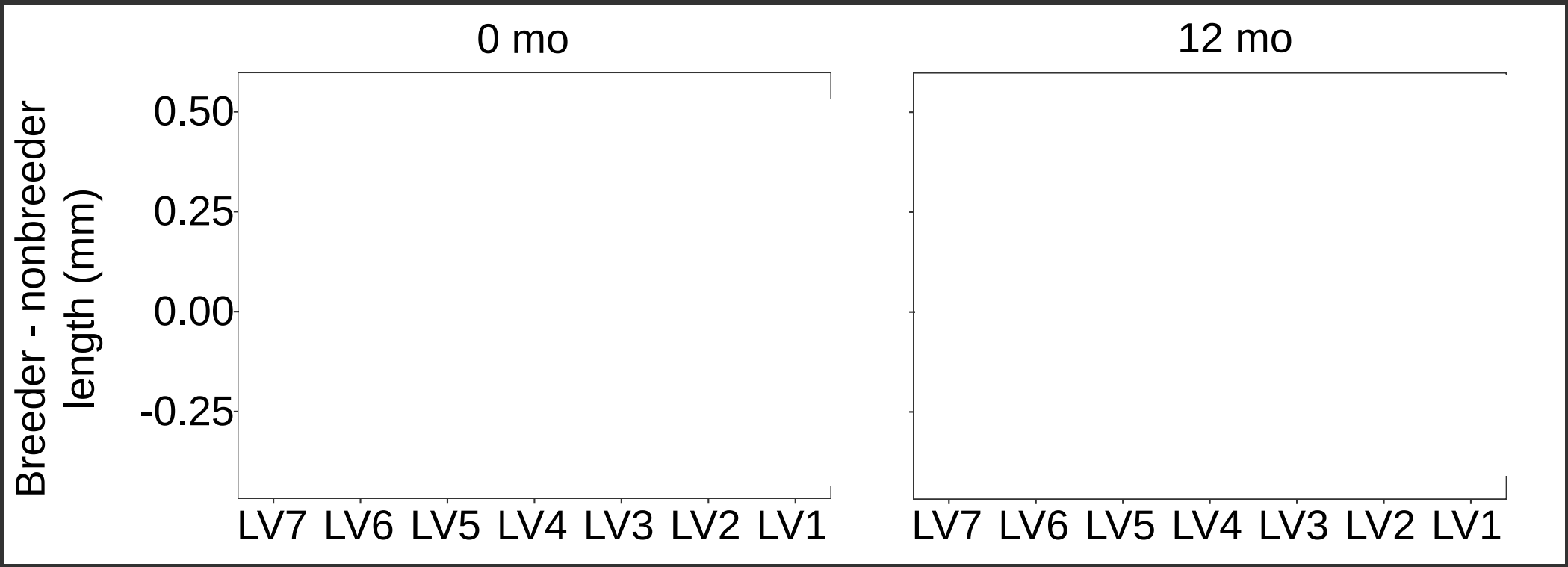


Johnston et al, *eLife*, 2021.

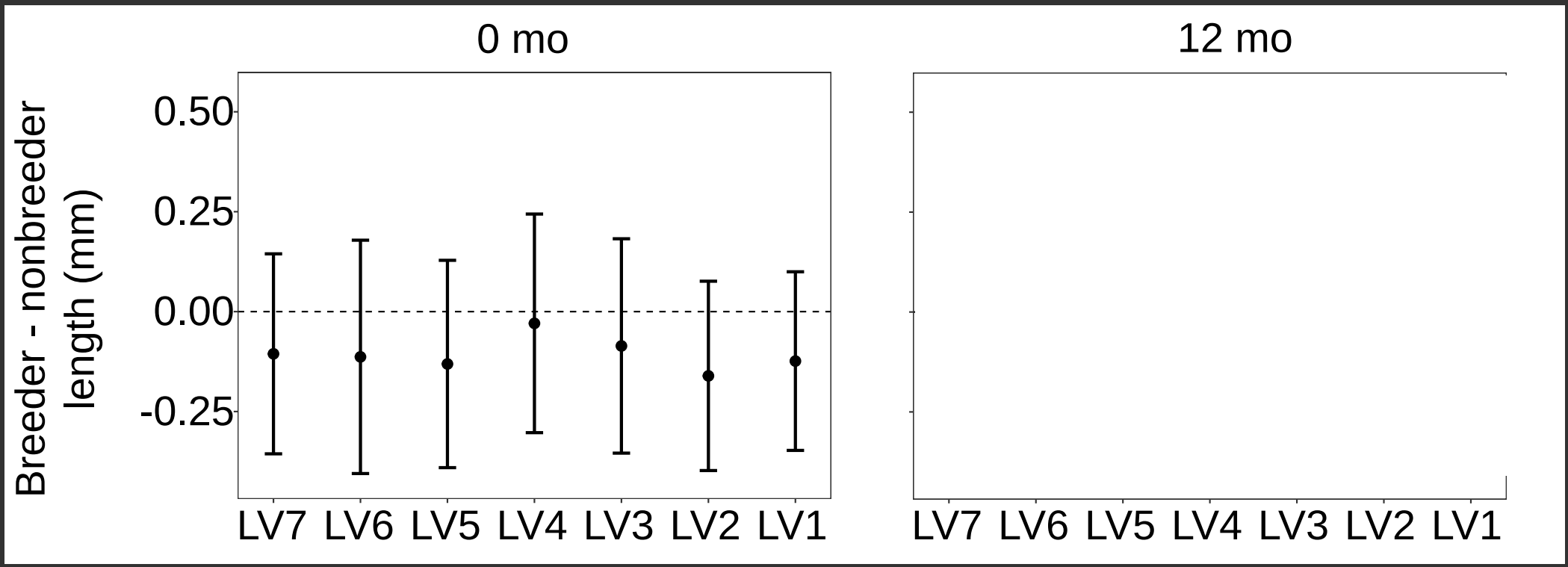


Johnston et al, *eLife*, 2021.

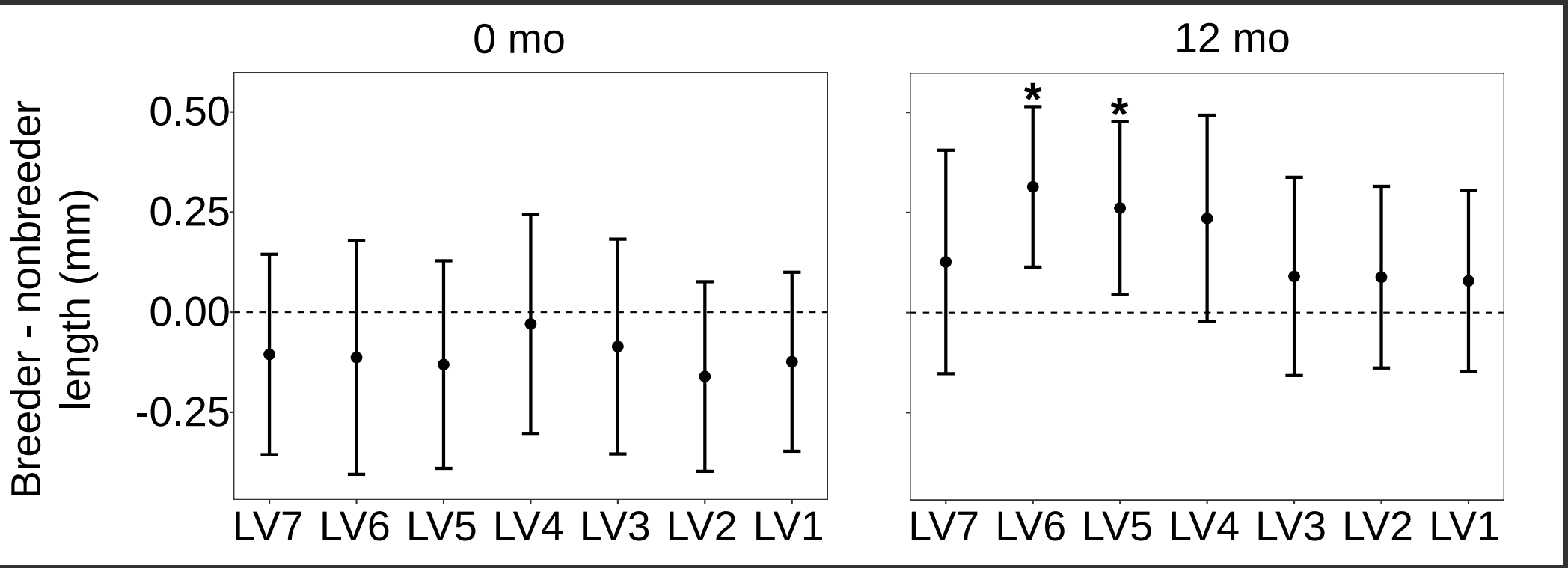

LV7 LV6 LV5 LV4 LV3 LV2 LV1
Femur
Tibia



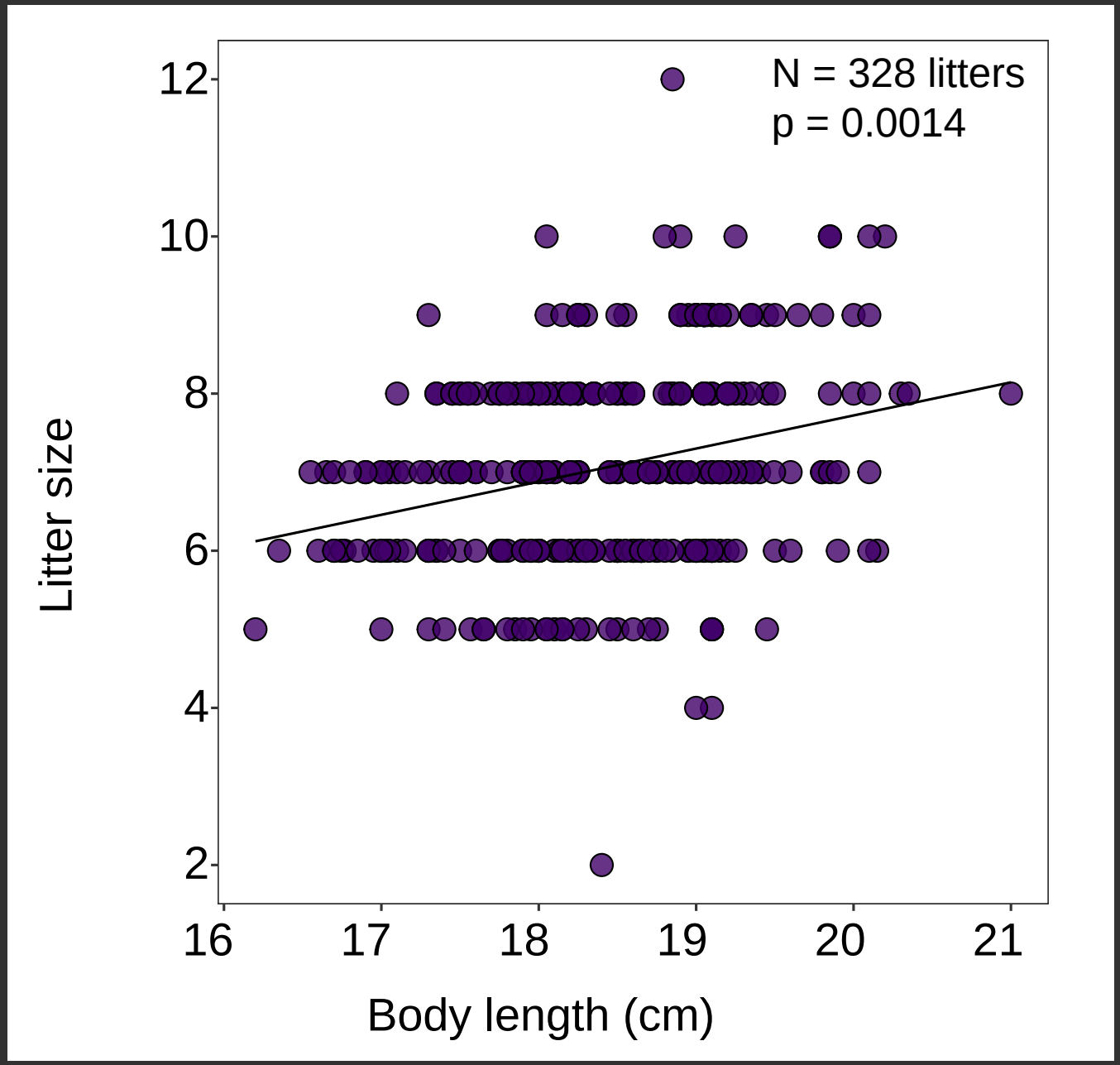
Johnston et al, *eLife*, 2021.



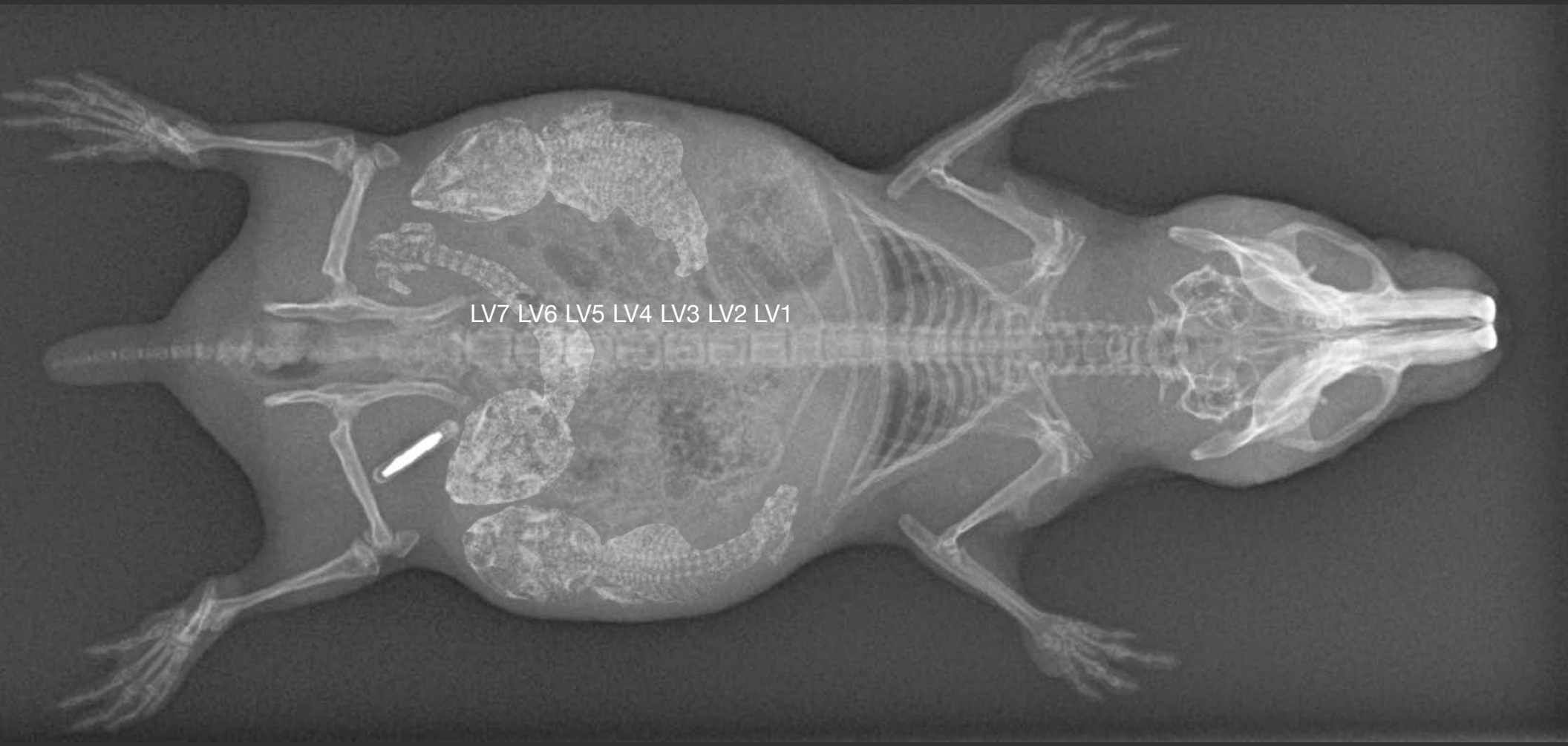
Johnston et al, *eLife*, 2021.



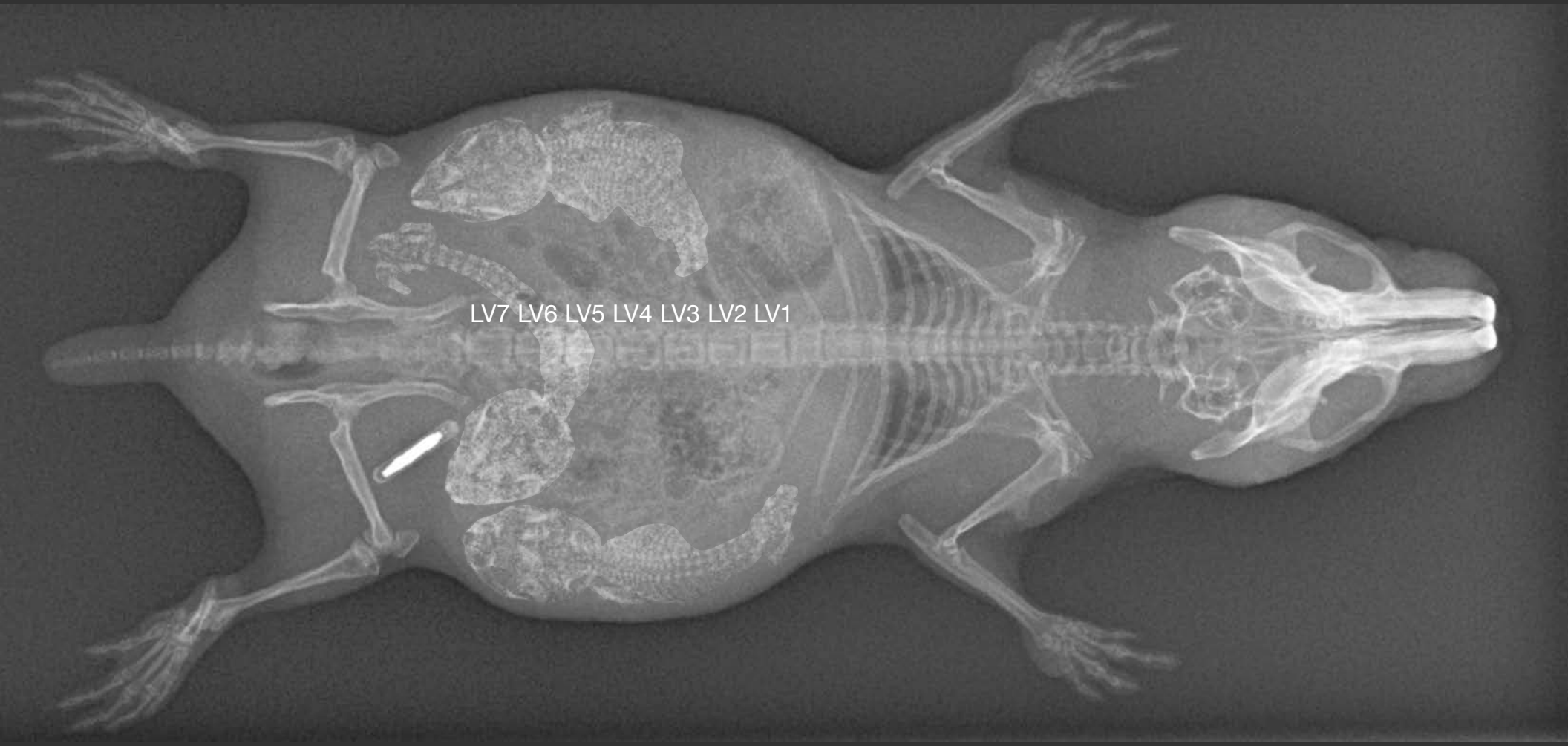
Johnston et al, *eLife*, 2021.



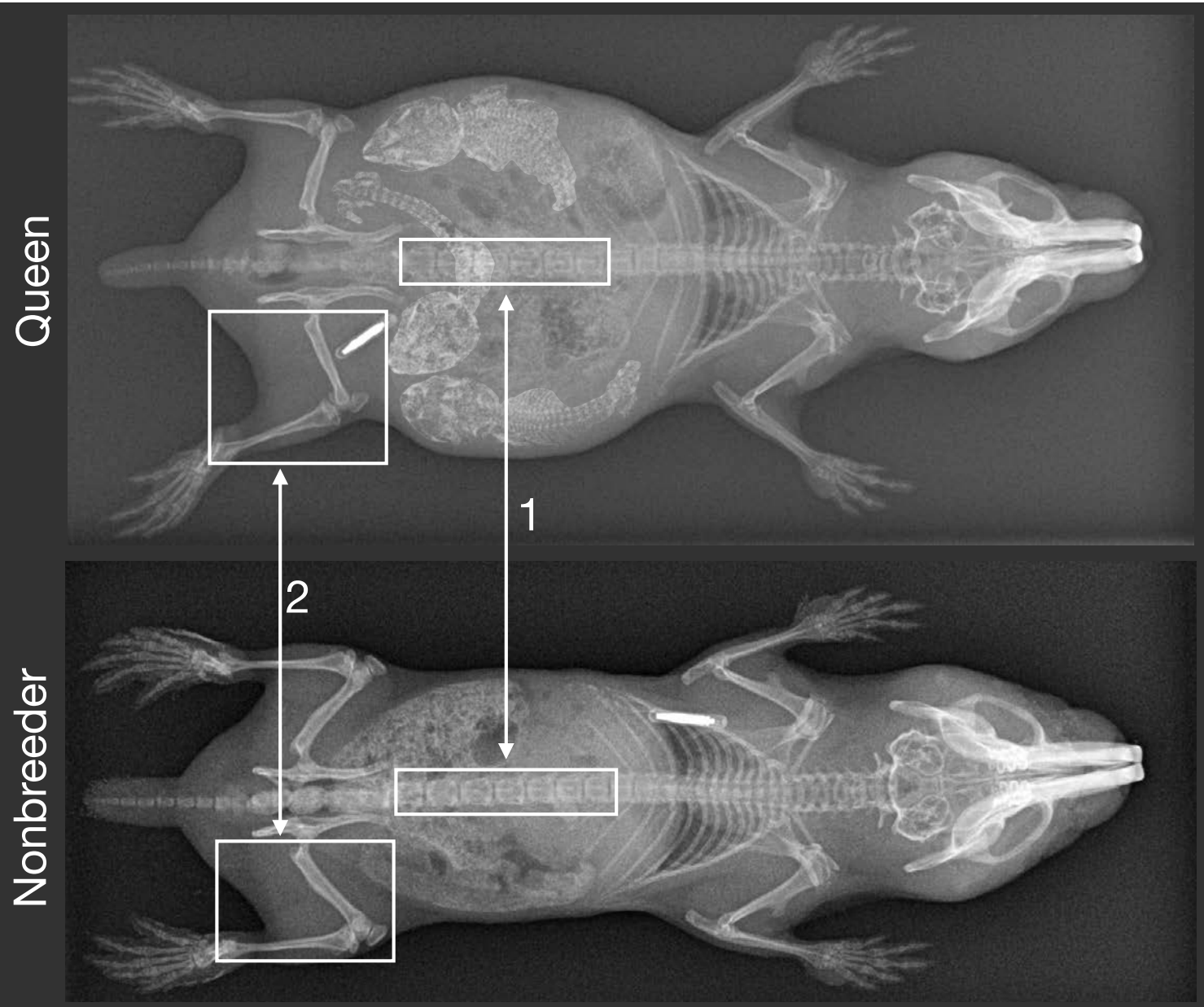
Johnston et al, *eLife*, 2021.


LV7 LV6 LV5 LV4 LV3 LV2 LV1

What are the gene regulatory changes associated with skeletal remodeling?




TUNG
LEI
LAB



Hypotheses:

1. Lumbar vertebrae GE will differ between queens and nonbreeders.
2. Long bone GE will not differ.

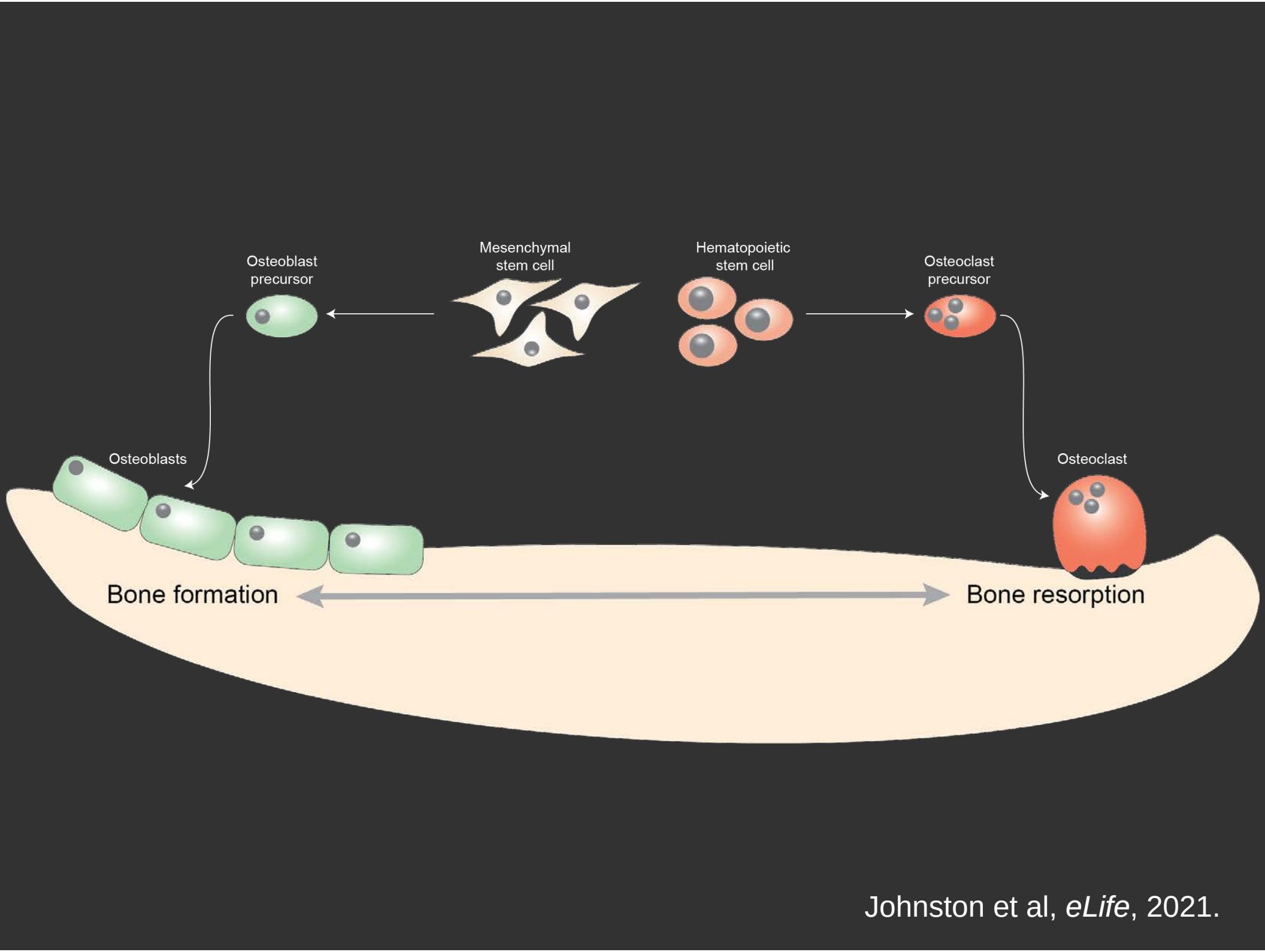
Cell culture for RNA-Seq

→ Isolate cells → Grow 5-10 days → RNA-seq

→ Isolate cells → Grow 5-10 days → RNA-seq

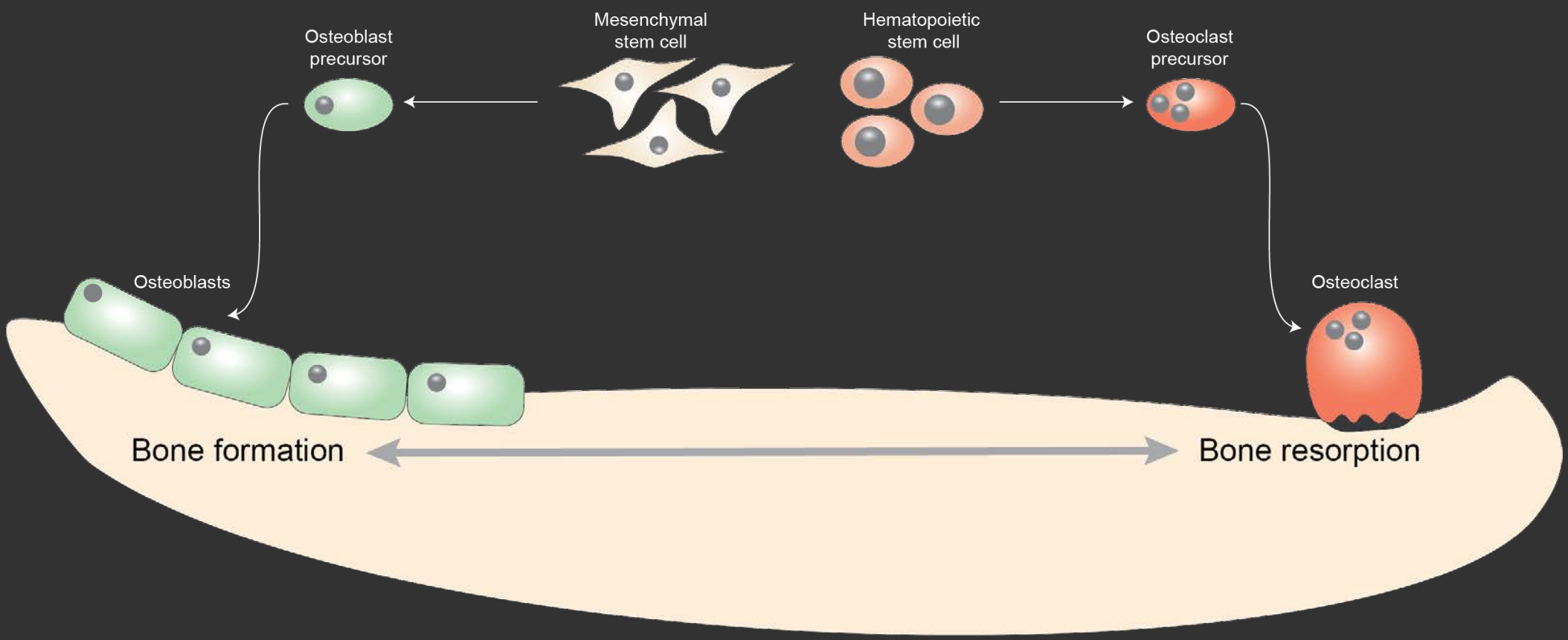
→ 70% EtOH

→ 70% EtOH



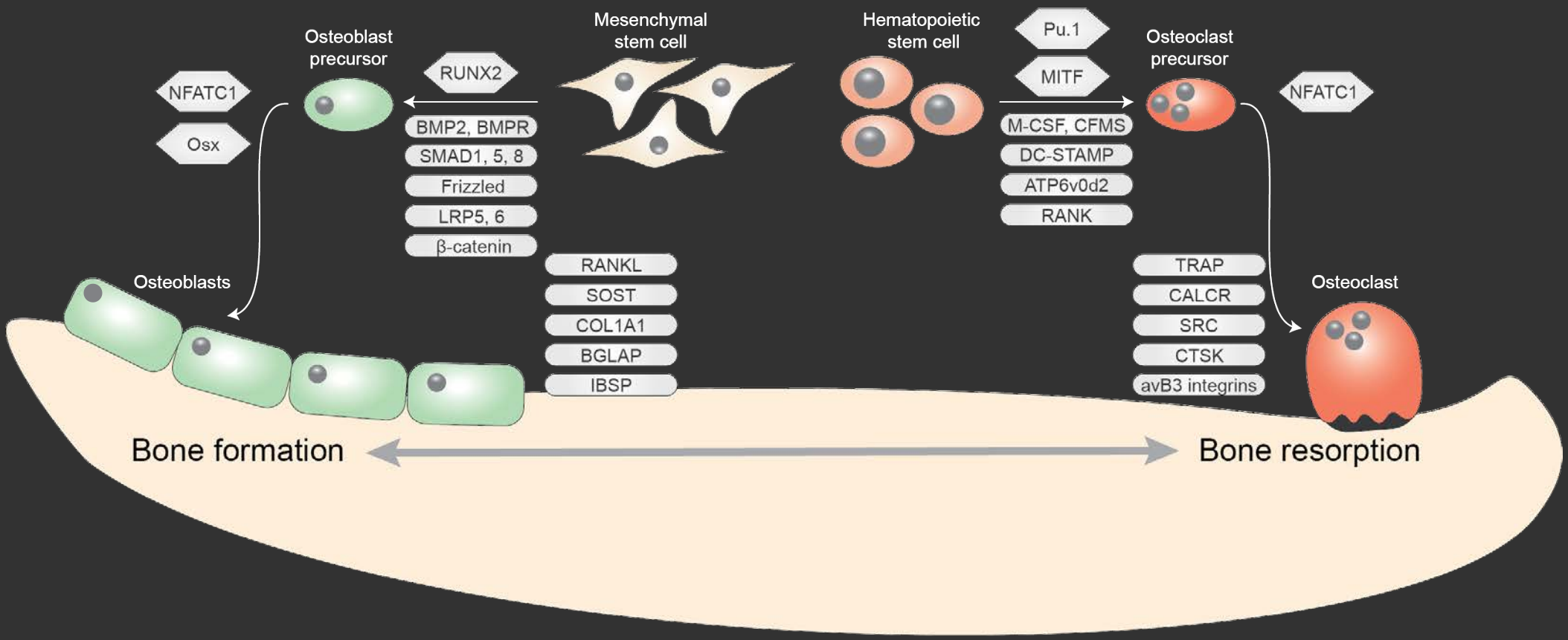
Johnston et al, *eLife*, 2021.

Positive regulation of bone resorption (OR = 91.14, p = 1.55×10^{-6})



Johnston et al, *eLife*, 2021.

Positive regulation of bone resorption (OR = 91.14, p = 1.55×10^{-6})



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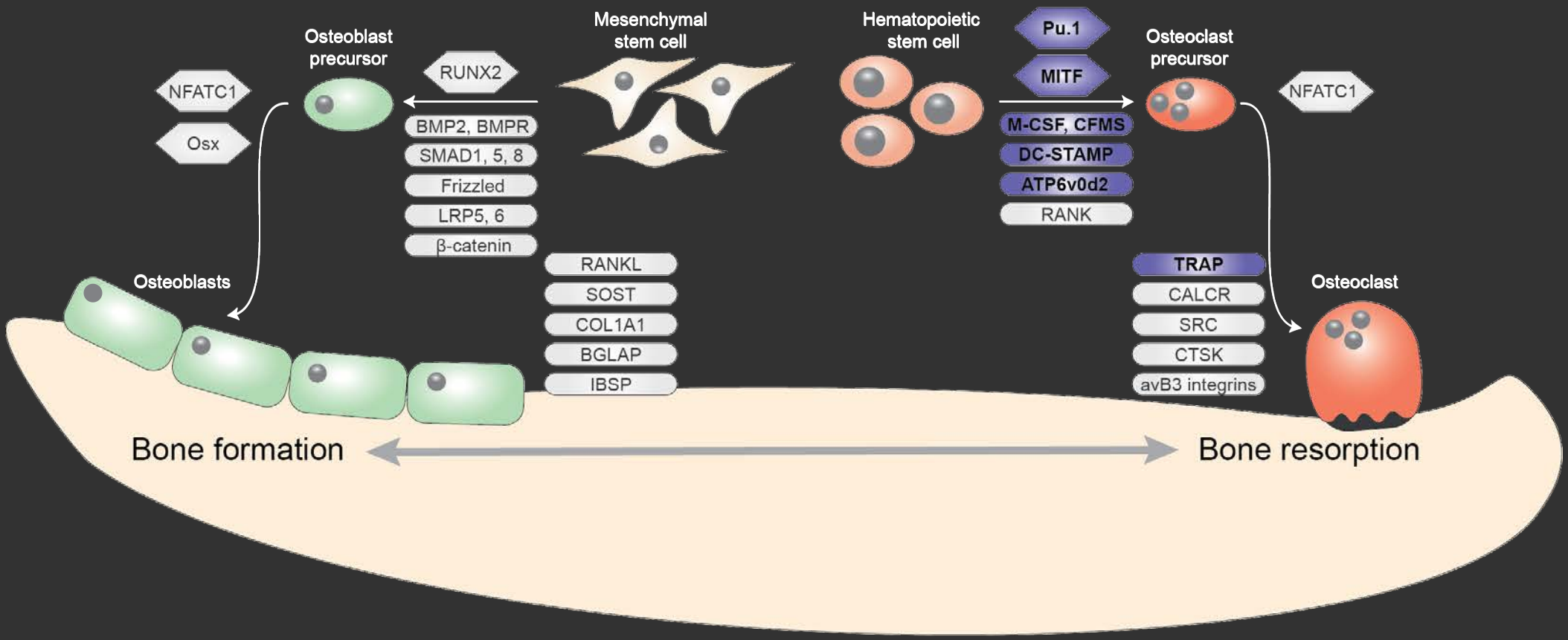
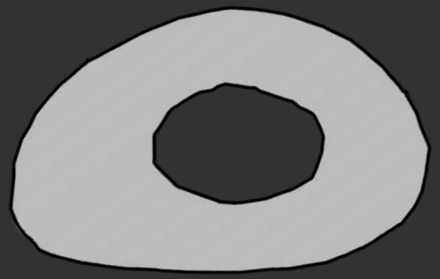
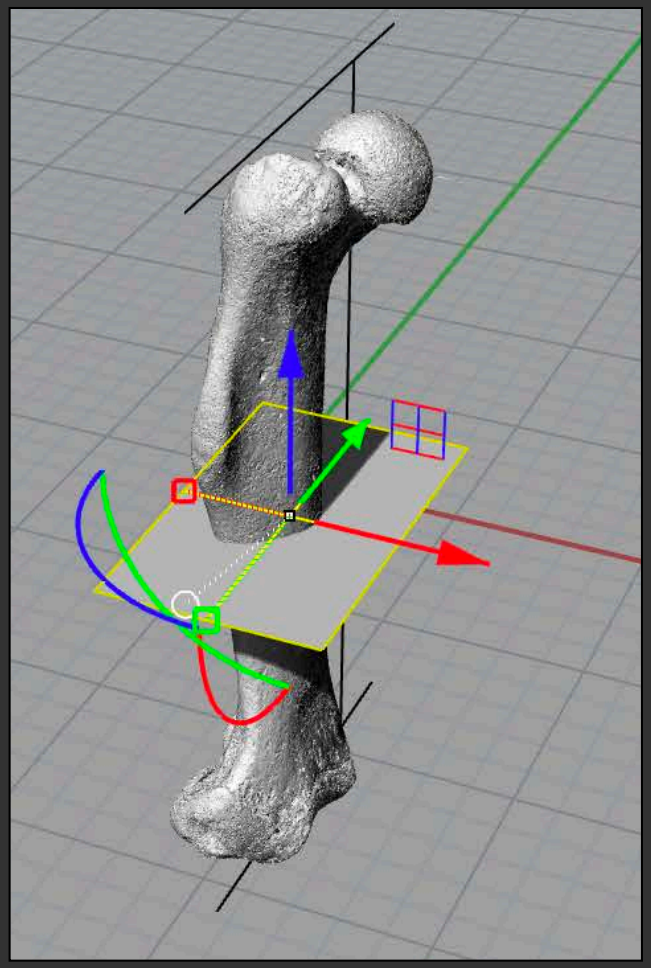
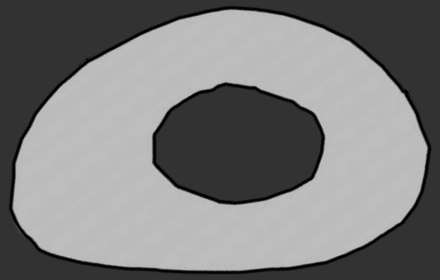
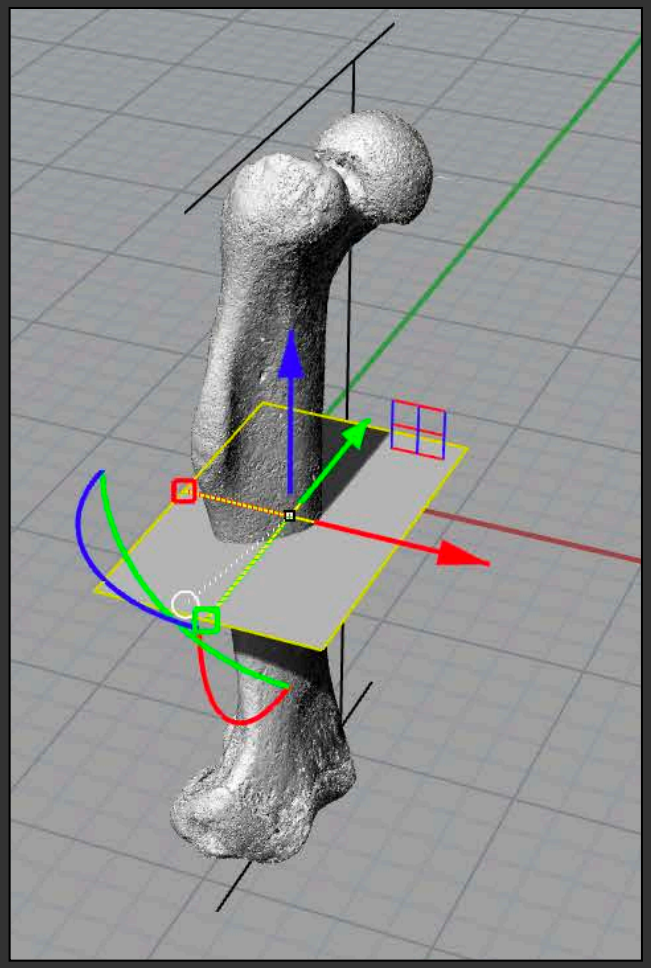


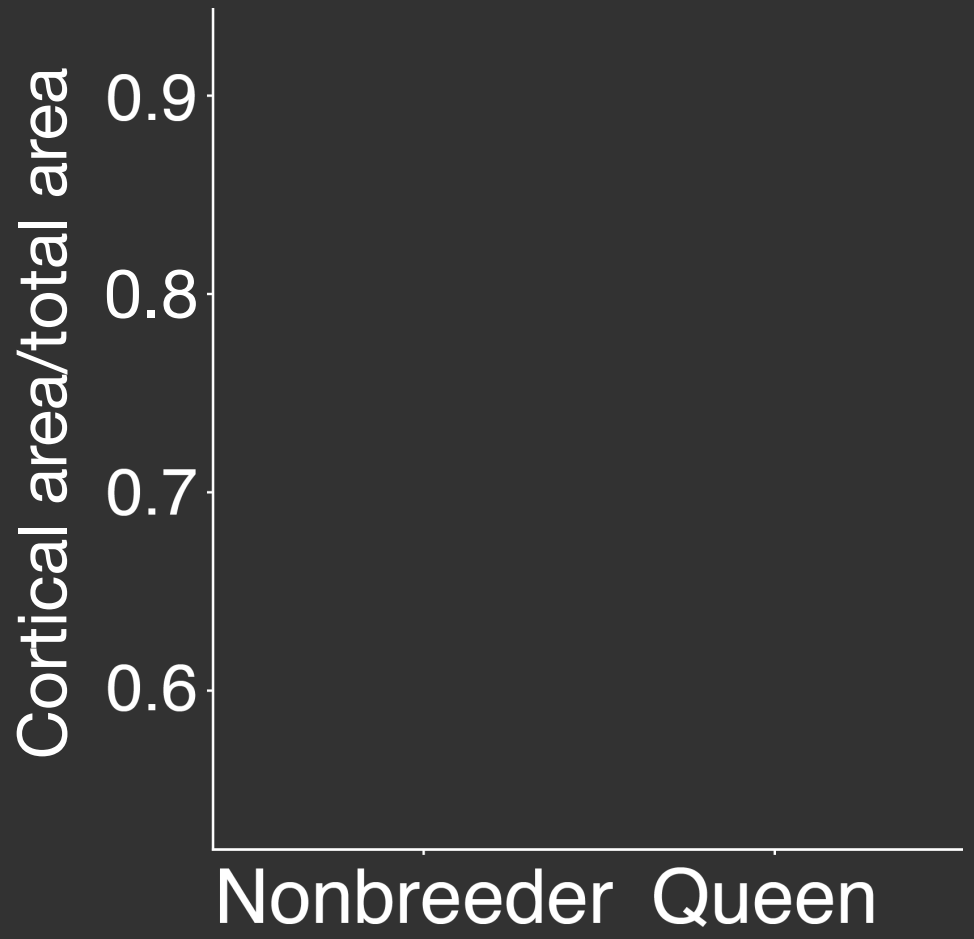
Johnston et al, *eLife*, 2021.

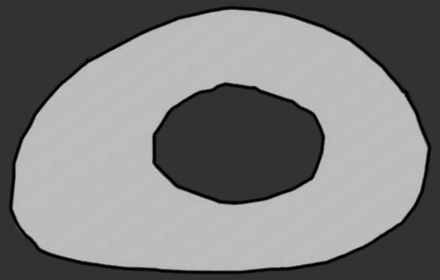


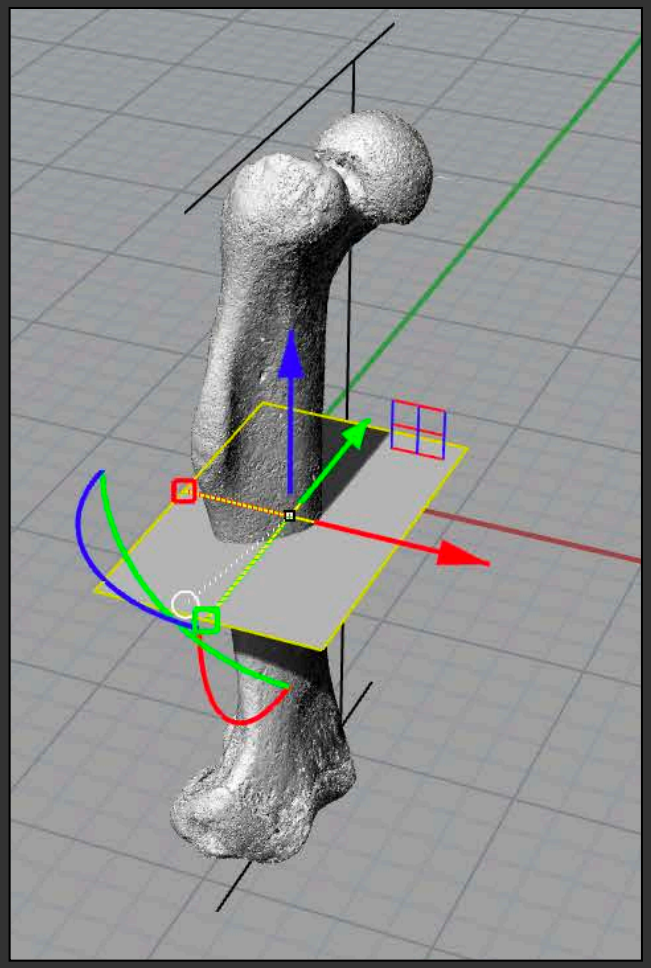


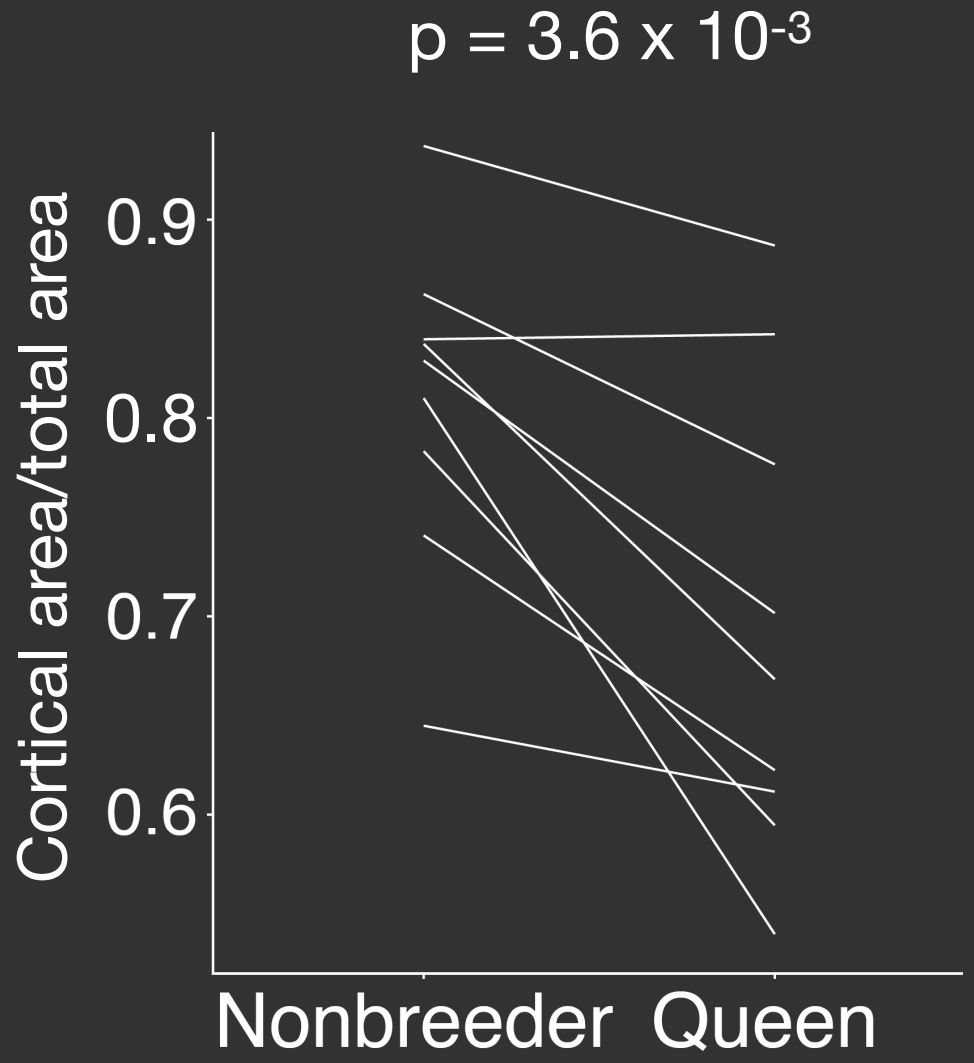


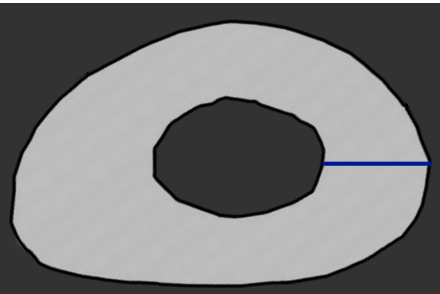


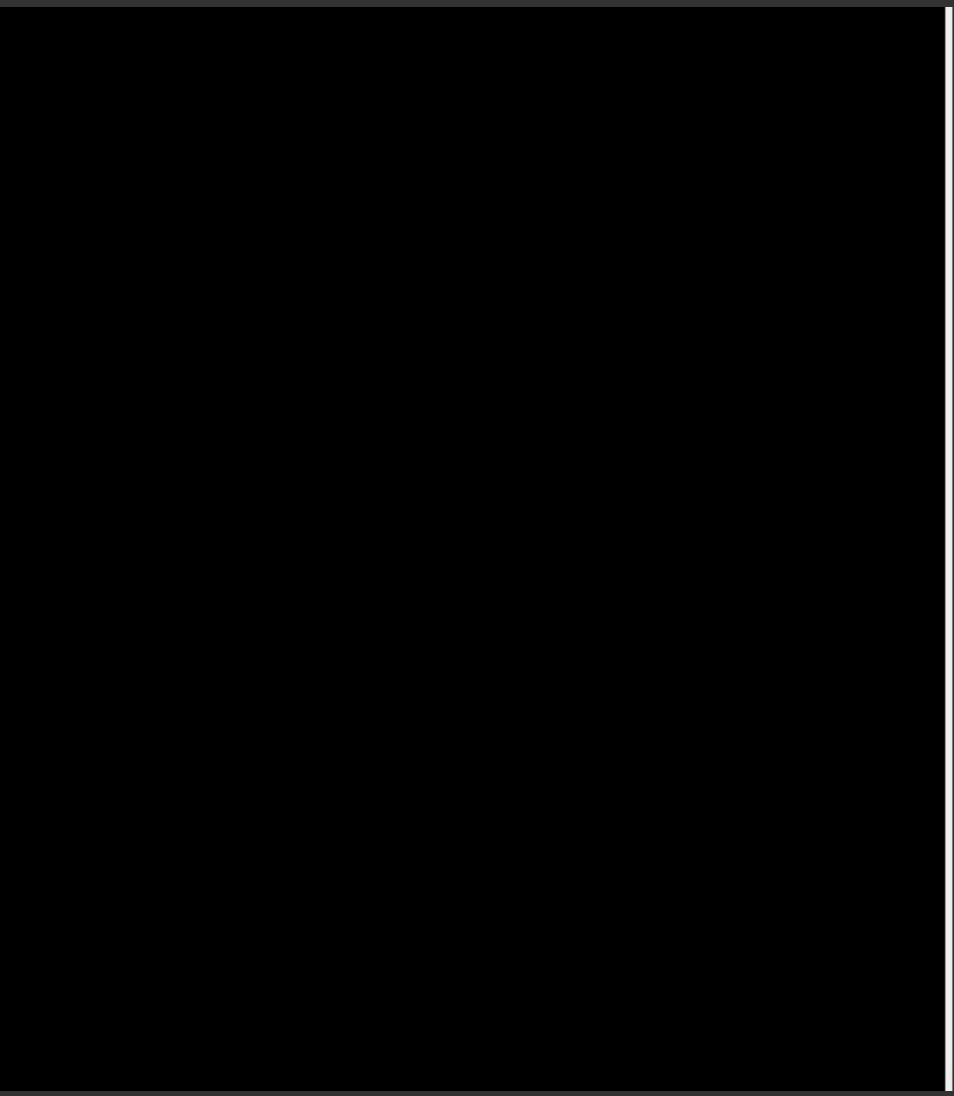

Cortical area/total area
0.9
0.8
0.7
0.6
Nonbreeder
Queen



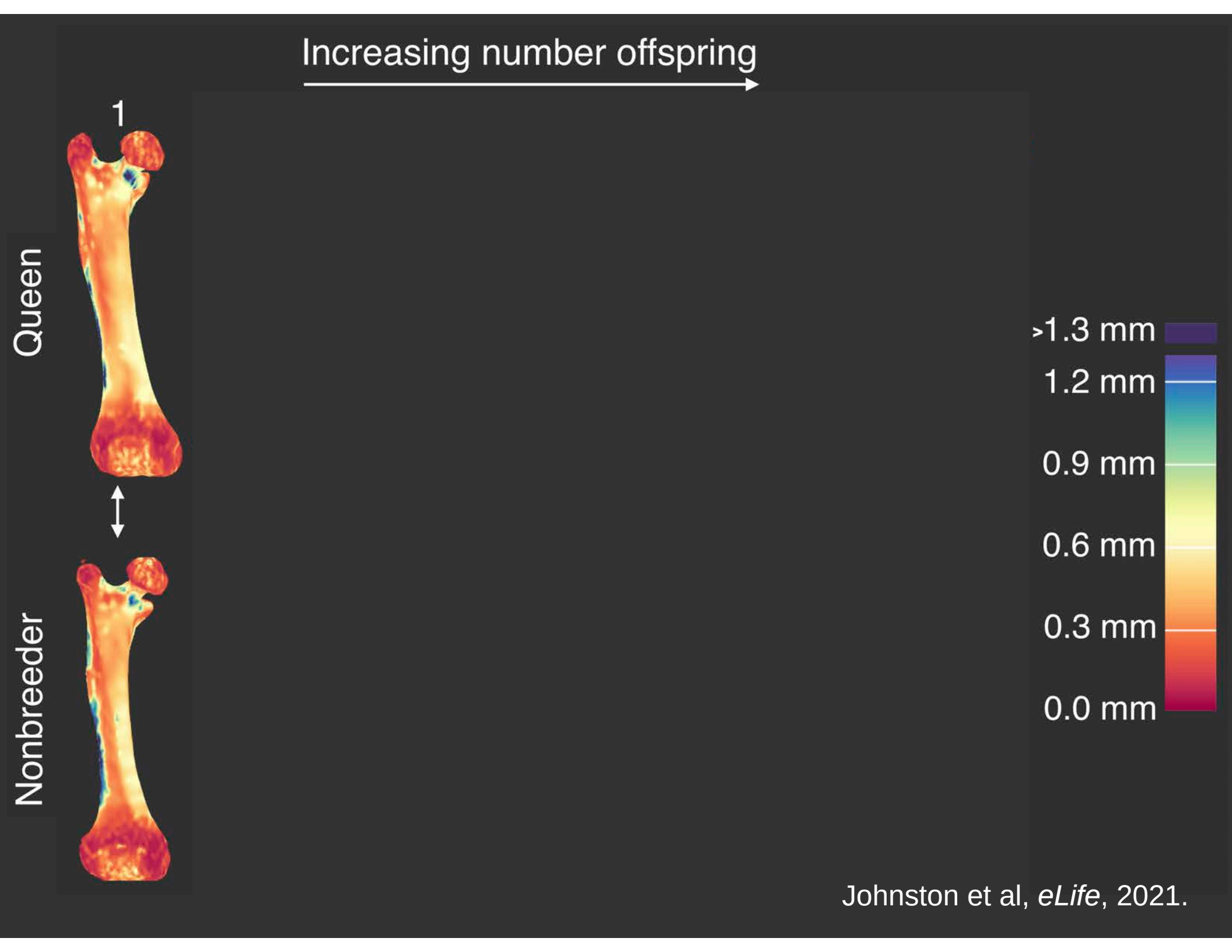



p = 3.6 x 10-3
Cortical area/total area
0.9
0.8
0.7
0.6
Nonbreeder
Queen

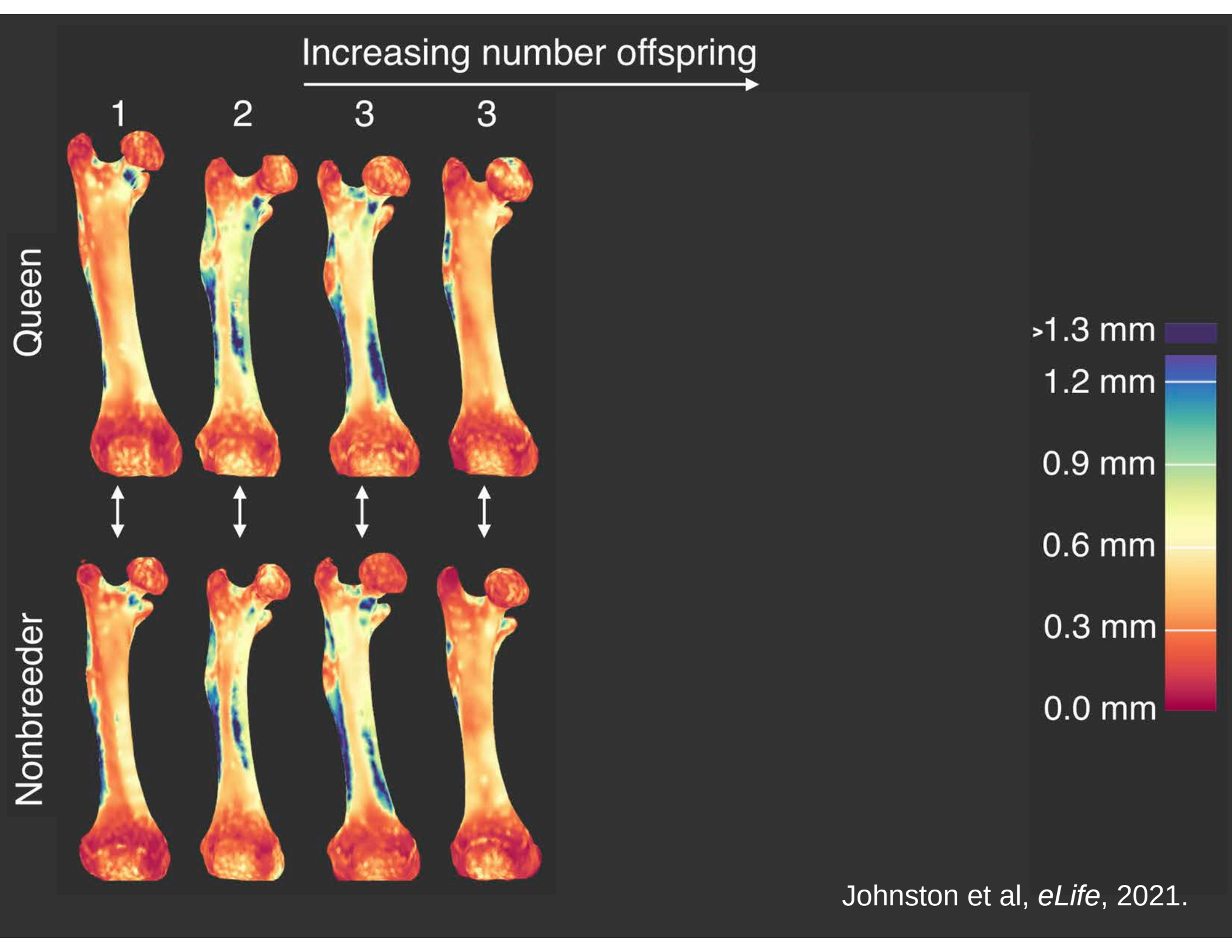




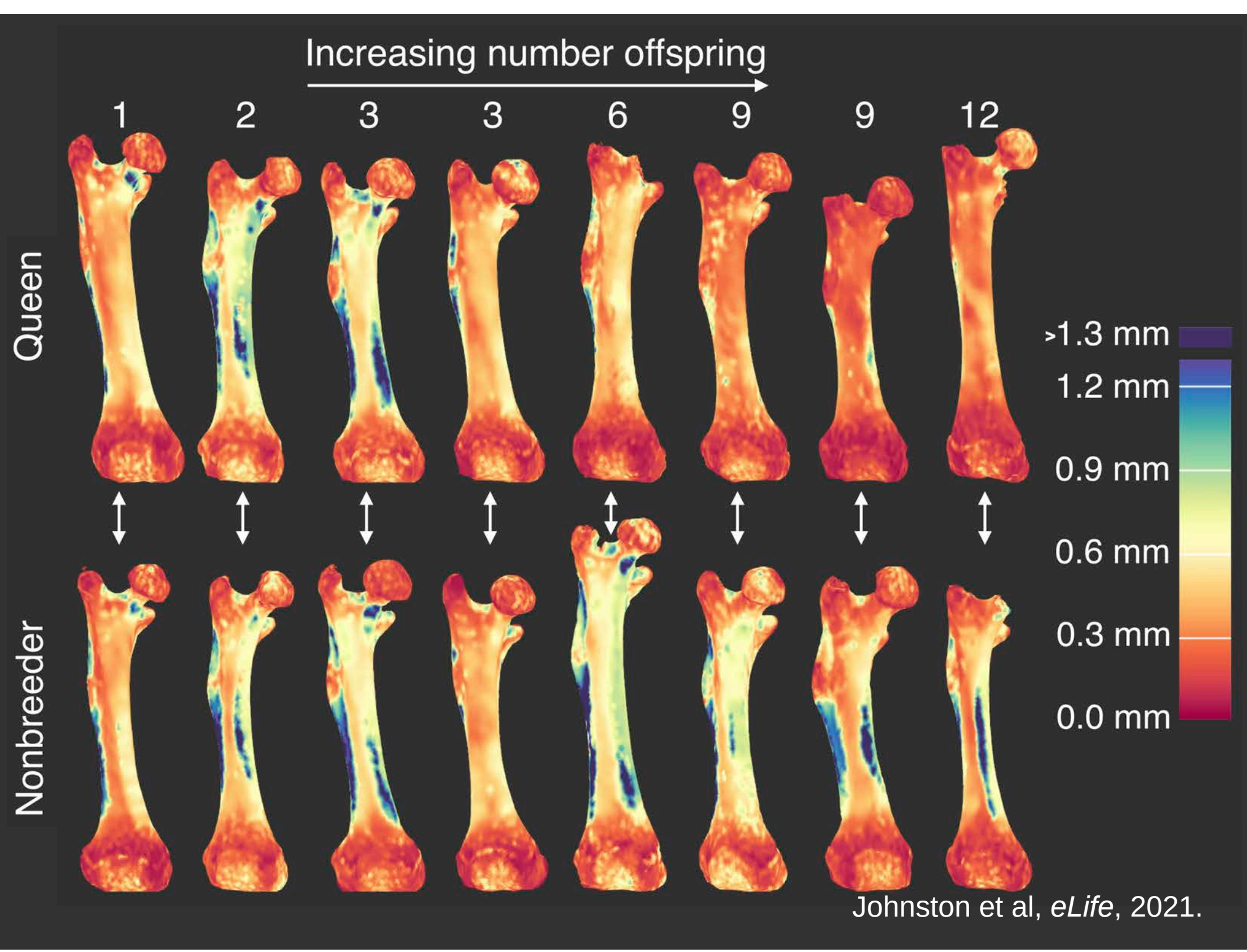

H
P
RA
L



Johnston et al, *eLife*, 2021.



Johnston et al, *eLife*, 2021.



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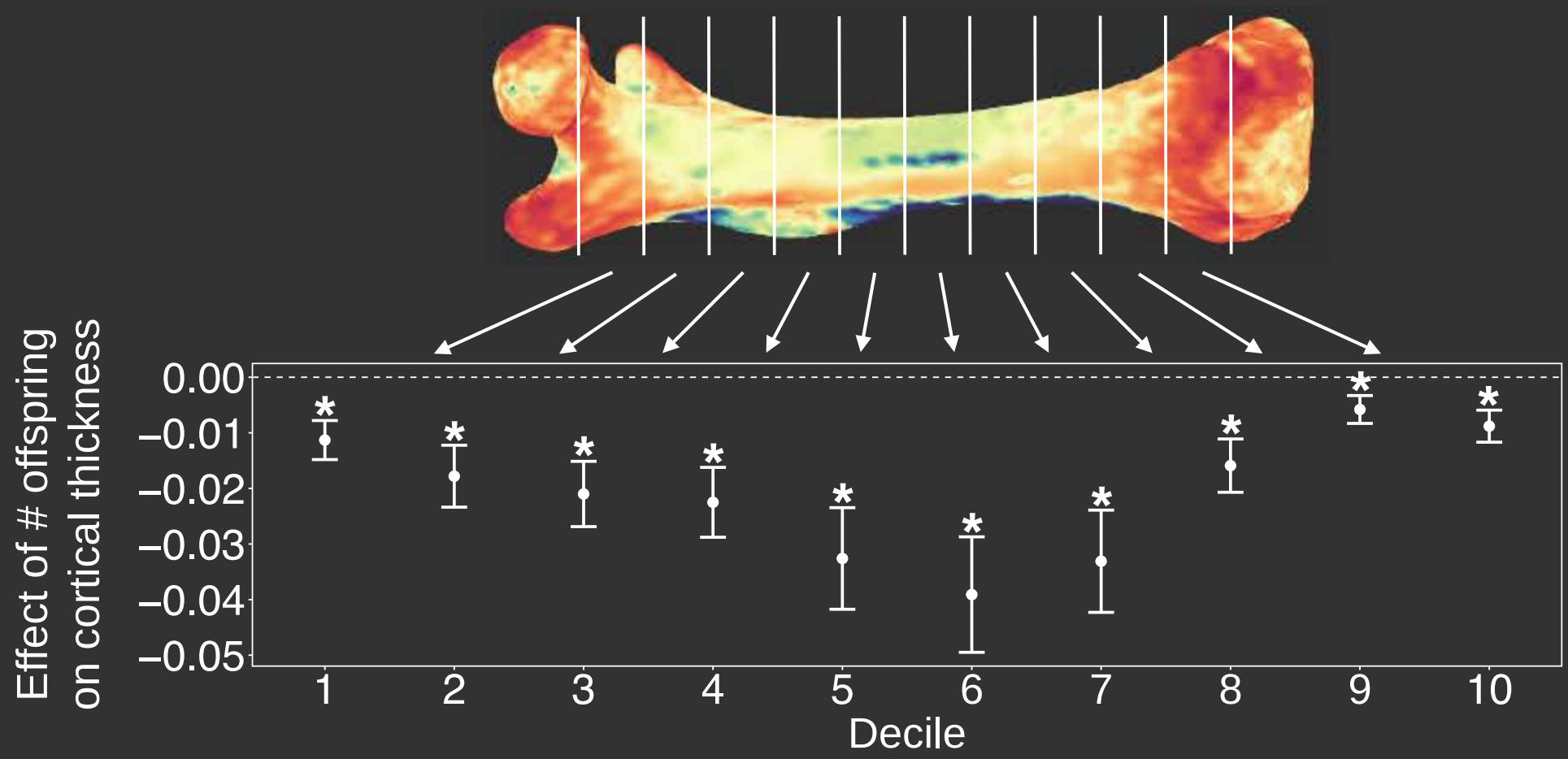

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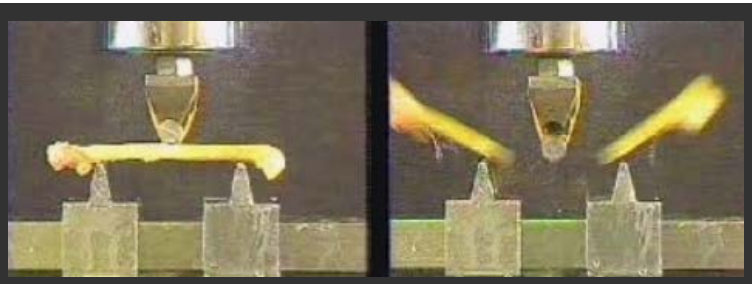

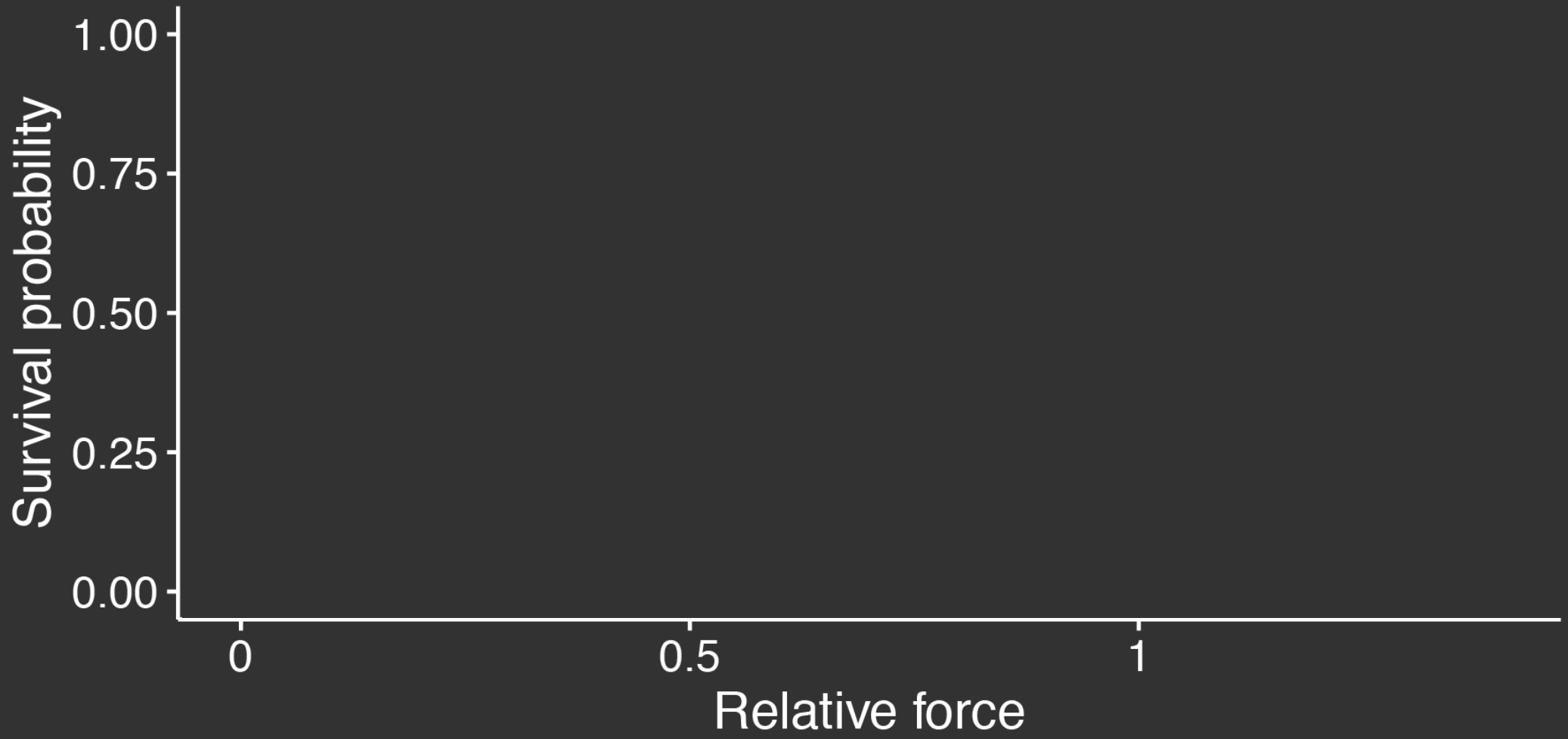

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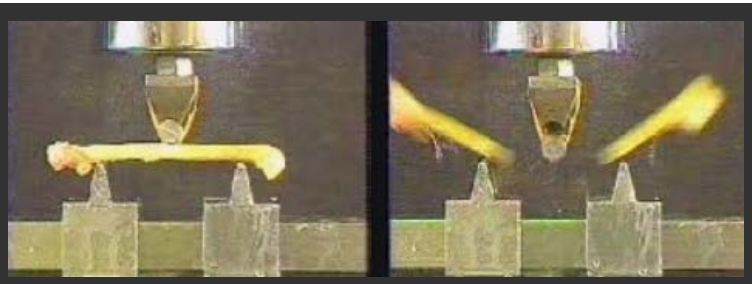


Queens Nonbreeders

p = 0.018

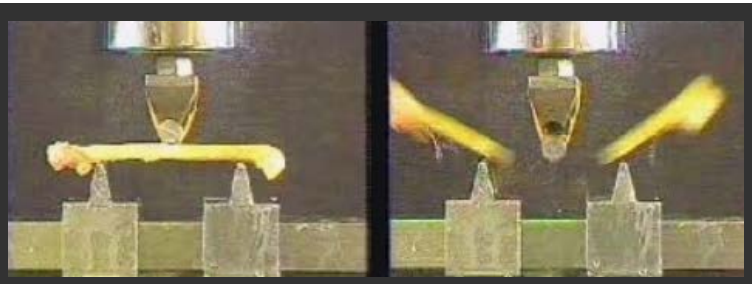
Survival probability

1.00
0.75
0.50
0.25
0.00

0 0.5 1

Relative force

Johnston et al, *eLife*, 2021.



Queens Nonbreeders Queens ≥ 6 offspring

p = 0.007

p = 0.018

Survival probability

1.00

0.75

0.50

0.25

0.00

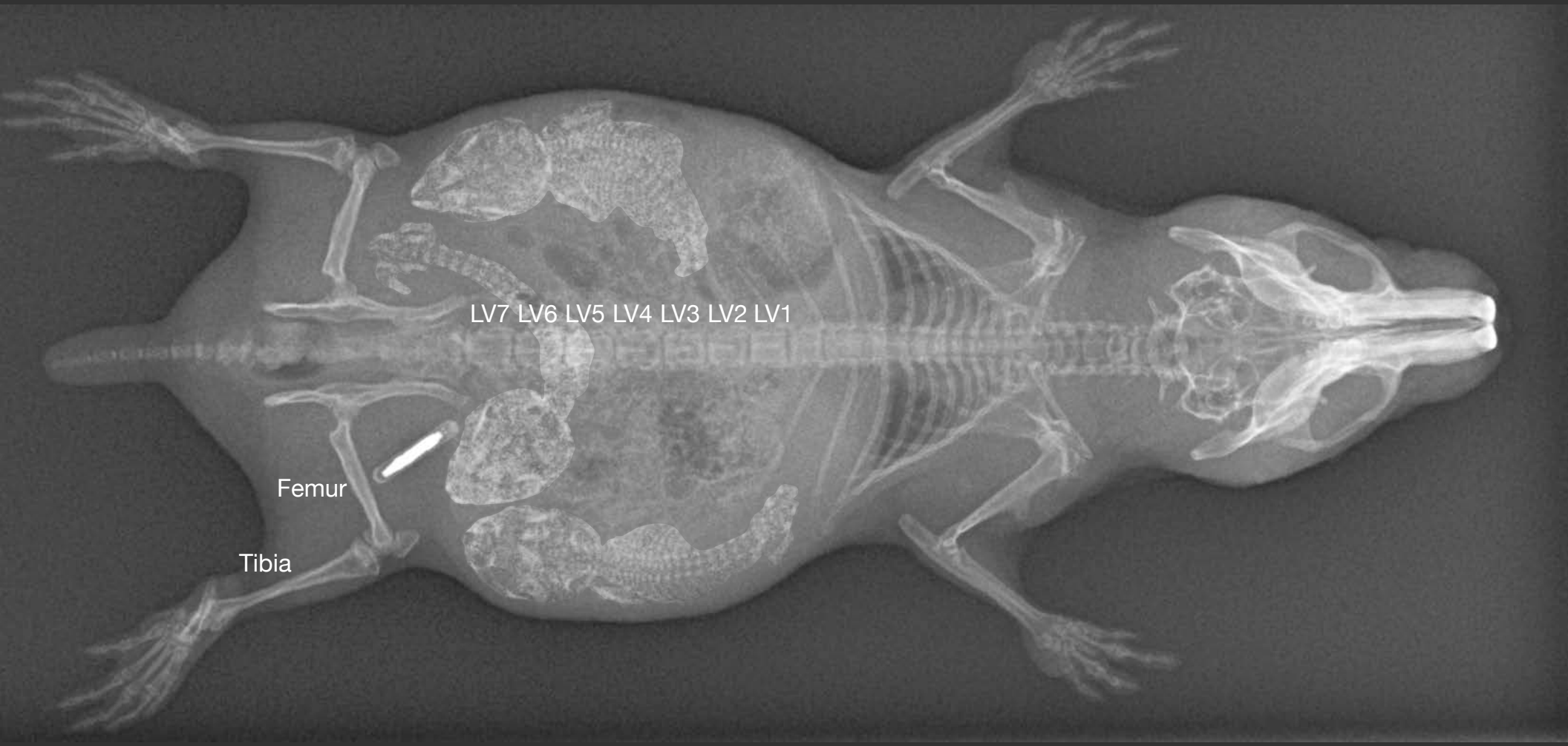
0

0.5

1

Relative force

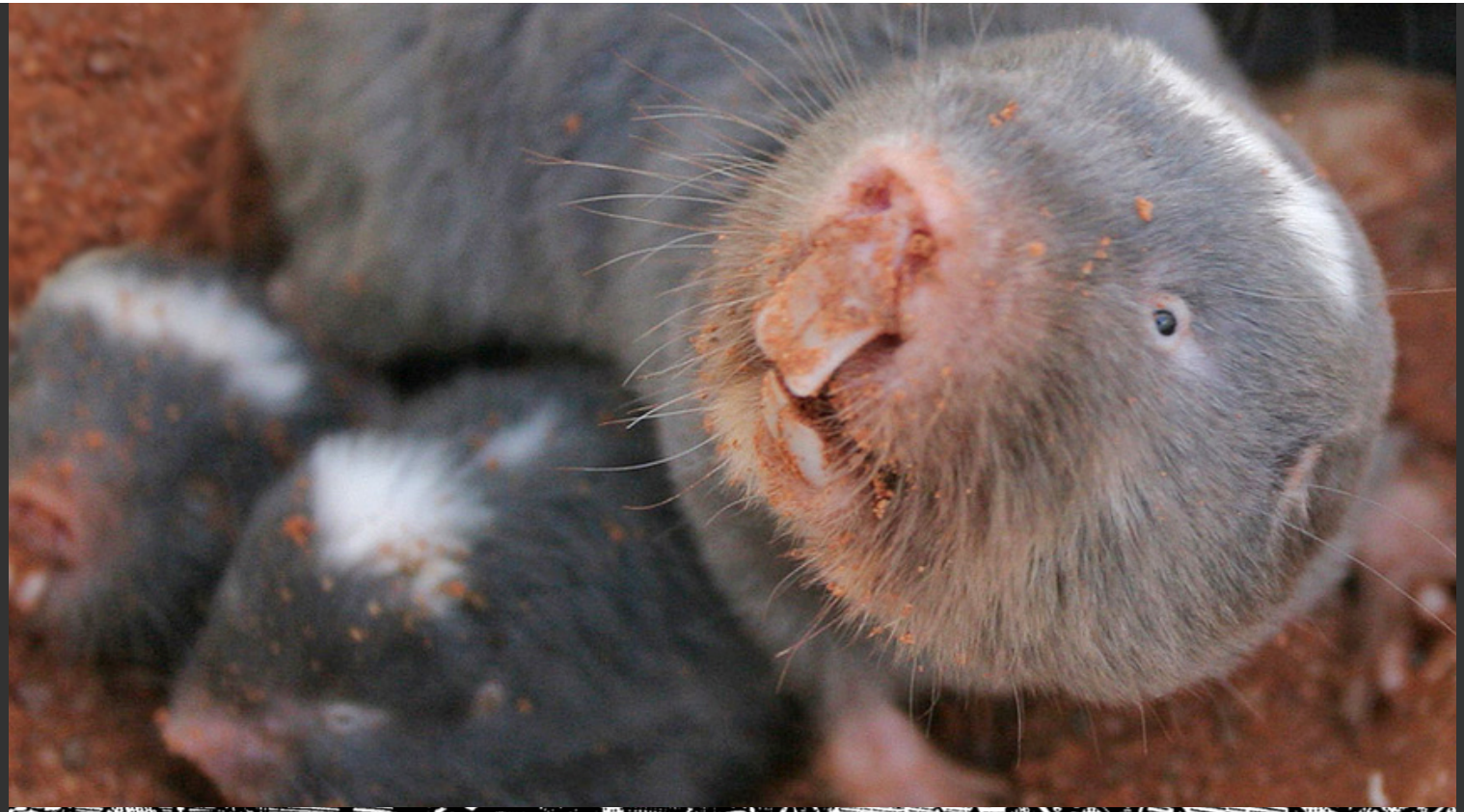
Johnston et al, *eLife*, 2021.


LV7 LV6 LV5 LV4 LV3 LV2 LV1
Femur
Tibia

Summary of results

Queens experience:

- Extensive morphological and gene regulatory changes
- Acceleration of lumbar vertebral growth, which appears to be adaptive
- Bone thinning, which appears to be costly and long-lasting



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Jenny Tung

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Alice Zhou
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