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Author(s):
Elsafadi, Sara; Hankele, Anna-Katharina; Giesbertz, Pieter; Ulbrich, Susanne E.

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Metabolic characterisation of the roe deer uterine fluid during diapause and elongation

Sara Elsafadi[1], Anna-Katharina Hankele[1], Pieter Giesbertz[2], Susanne E. Ulbrich[1]

[1] ETH Zurich, Animal Physiology, Institute of Agricultural Sciences, Zurich, Switzerland

[2] Else Kröner-Fresenius-Center of Nutritional Medicine, TUM School of Life Sciences, Technical University of Munich, Freising, Germany

Introduction

During embryonic diapause in the European roe deer, there is a noticeable decrease in growth and metabolism for a period of 4-5 months. The reactivation phase aligns with embryo elongation (1). Our aim is to determine whether the uterine fluid (UF) establishes a supportive environment that delays embryo growth in diapause and aids its reactivation during elongation. We therefore assessed the metabolic profiles of nonpoalar lipids, polar metabolites, acylcarnitines, and polyamines in the UF of roe deer during at diapause and elongation.

Methods

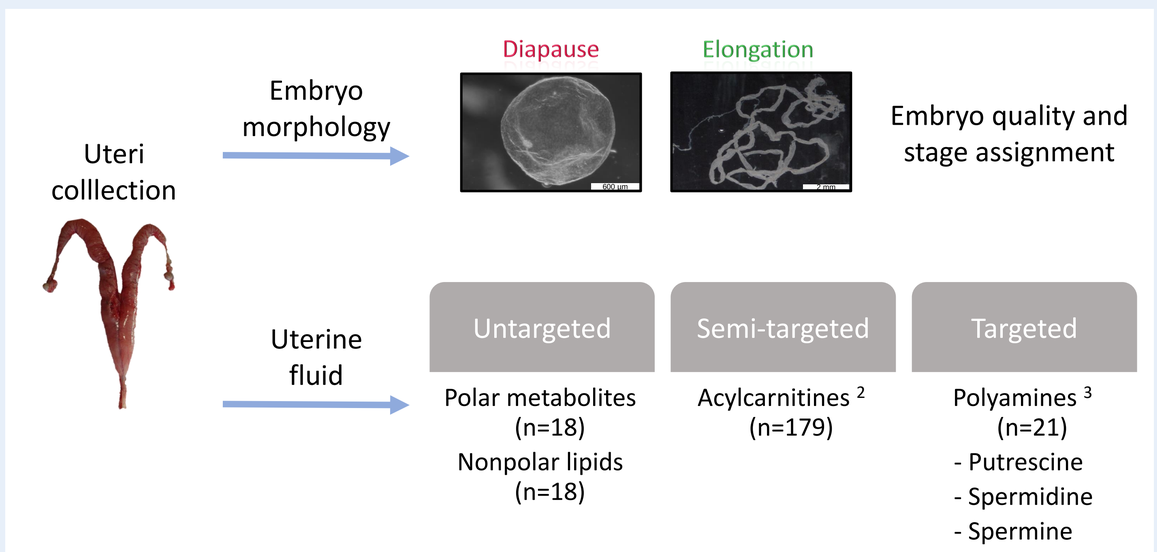

Fig. 1: Methods of characterizing the roe deer metabolome in diapause and elongation.

Results

1) Polar metabolites

A total of 103 differentially abundant metabolites clustered based on stage. TCA cycle intermediates and the amino acids methionine, glutamine and asparagine increased upon elongation.

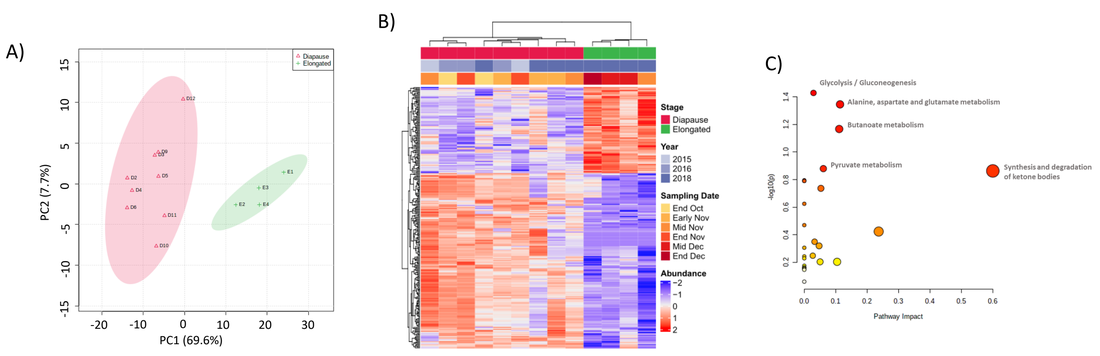

Fig. 2: (A) PCA, **(B)** heatmap and **(C)** functional analysis of the significantly differentially abundant metabolites in the roe deer UF during diapause and elongation. (p-value < 0.01; $-0.5 \leq \log_2 FC \leq 0.5$).

2) Nonpolar lipids

A total of 406 differentially abundant lipids clustered based on stage. Sphingomyelins, phosphatidylserines and phosphatidylinositols increased while triglycerides and diglycerides decreased upon elongation.

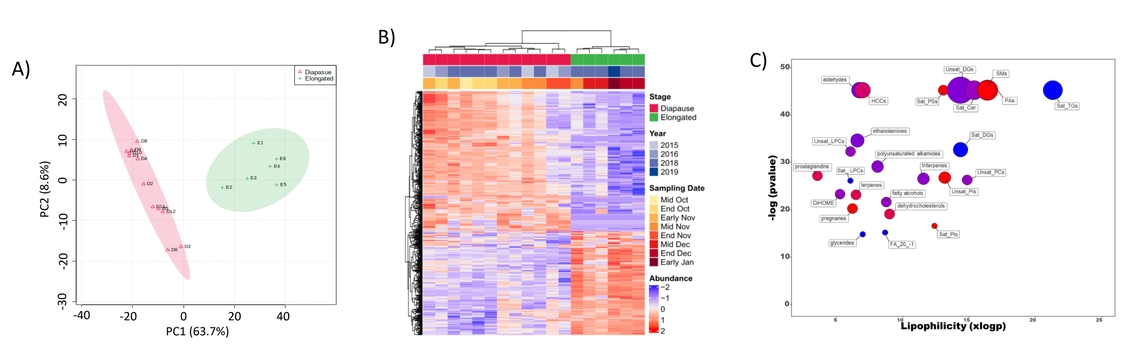

Fig. 3: (A) PCA, **(B)** heatmap and **(C)** chemRICH plot of the differentially abundant lipids in the roe deer UF. Cluster size represents the number of lipids. Colors indicate the ratio of elongated to diapause: red=1 and blue=0. (p-value < 0.01; $-0.5 \leq \log_2 FC \leq 0.5$).

3) Acylcarntines

Of the 29 total acylcarntines detected, 6 fatty-acid derived acylcarnitines significantly increased upon elongation.

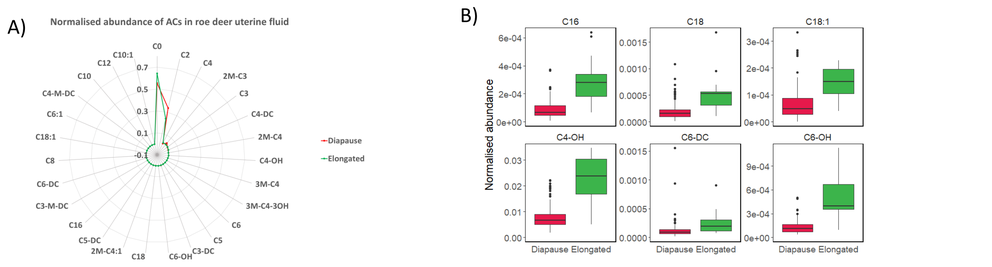

Fig. 4: Normalized abundance of **(A)** all quantified and **(B)** differentially abundant acylcarnitines in roe deer UF during diapause and elongation. (p-value < 0.01 and $\log_2 FC \geq 2$).

4) Polyamines

Spermidine (FC = 7.3) and spermine (FC = 2.6) significantly increased upon elongation whereas putrescine levels did not significantly change.

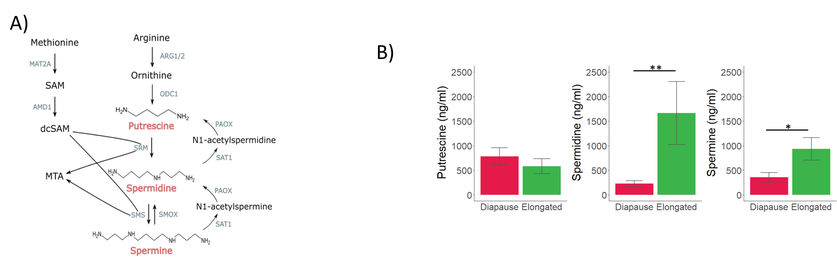

Fig. 5: (A) The polyamine biosynthesis pathway. **(B)** Concentration of putrescine, spermidine and spermine in the roe deer UF in diapause and elongation. (p-values: ** = 0.004786, * = 0.0357).

Conclusion

Changes in the roe deer uterine environment likely promote embryo elongation by enhancing fatty acid breakdown for membrane formation and utilizing glycolysis to fulfill energy requirements. Spermidine appears crucial in reactivation and growth, while the sphingolipid synthesis pathway may be connected to one-carbon metabolism. These findings provide valuable insights into roe deer reproduction and offer potential applications for fertility treatments and conservation efforts.

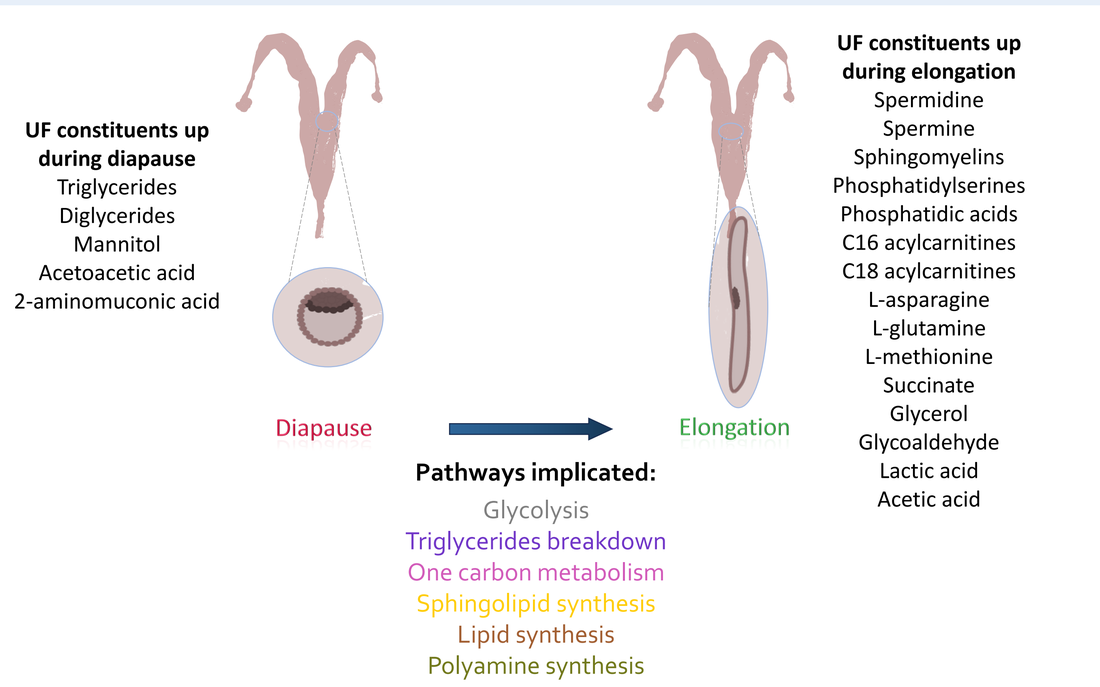

Fig. 6: Schematic summary of the roe deer uterine fluid metabolome.

References

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