How does increased UV-B radiation affect the malformation rate in pollen grains?

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Background

Malformed pollen grains are found in sediments representing major extinction events throughout Earth's history (Fig 1).

What causes these malformations is not yet fully understood, but a key hypothesis proposes a link between pollen malformation rate and exposure to UV-B radiation (Benca et al. 2018, Looy et al. 2001)

We used a greenhouse experiment to quantitively examine the effects of UV-B radiation on pollen malformation rate in branch cuttings from *Pinus sylvestris.*

End-Permian fossilized pollen

Normal | Malformations

A | 20 µm | B | C | D | E | F | G | H

Experimentally irradiated pine pollen

Normal | Malformations

I | 20 µm | J | K | L | M | N | O | P

Fig 1 from Benca et al. (2018) showing different malformations in *Pinus mugu* pollen. A–H is pollen from end-Permian sediments and I-P is irradiated pollen from a greenhouse experiment. Our study aimed to replicate this study using *P. sylvestris* branches.

Experimental design and methods

Branches from three *Pinus sylvestris* trees from Bontveit, Vestland, Norway were sampled in April 2022 and transferred to a greenhouse.

The branches were divided into five frames, with each frame containing a UV-B treatment and a control (no UV-B radiation).

Pollen was sampled from the branches in May 2022, transferred to microscope slides and 600 pollen grains per slide were assessed for pollen malformations.

Malformation rate in the control and the UV-B treatment were compared using linear mixed effects models with each frame set as a random effect in R.

Key findings II

Fig 3 shows a mixed effect model of the malformation rate in the UV-treatments. The grey and purple squares shows the mean value, whilst each black symbol represents a tree.

We see a significant effect between the UV-B treatment and the malformation rate, with a p-value of 0.0252.

The estimated random effect between the frames is large, indicating large differences between the frames due to light gradients in the greenhouse.

	effect	group	term	estimate	std.error	statistic	p.value
	<chr>	<chr>	<chr>	<dbl>	<dbl>	<dbl>	<dbl>
1	fixed	NA	(Intercept)	-6.05	0.281	-21.6	5.12e-103
2	fixed	NA	TreatmentUV	0.580	0.259	2.24	2.52e- 2
3	ran_pars	Frame	sd__(Intercept)	0.404	NA	NA	NA

Table 1 shows the outputs from the mixed effect modeling used to investigate the effects of UV-B radiation on malformation rate.

Key findings I

Fig 2 shows a sample of the malformations found in the experiment.

By comparing the malformations found in our experiment (fig 2) to the malformations found by Benca et al.(fig 1), we see similarities in several of the mutations. The pollen malformations we observed share some of the same malformations found in the fosilized pollen (fig 1).
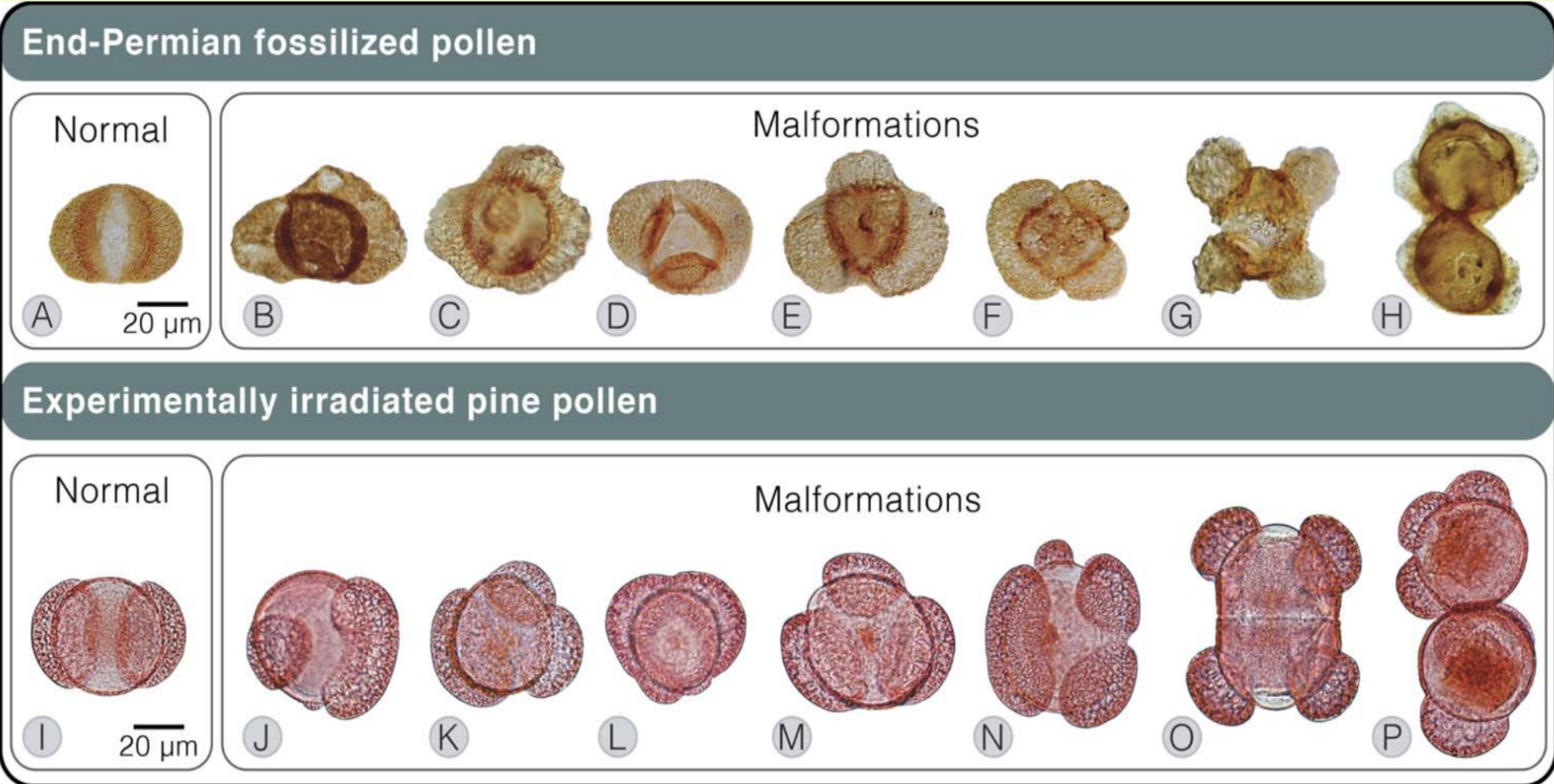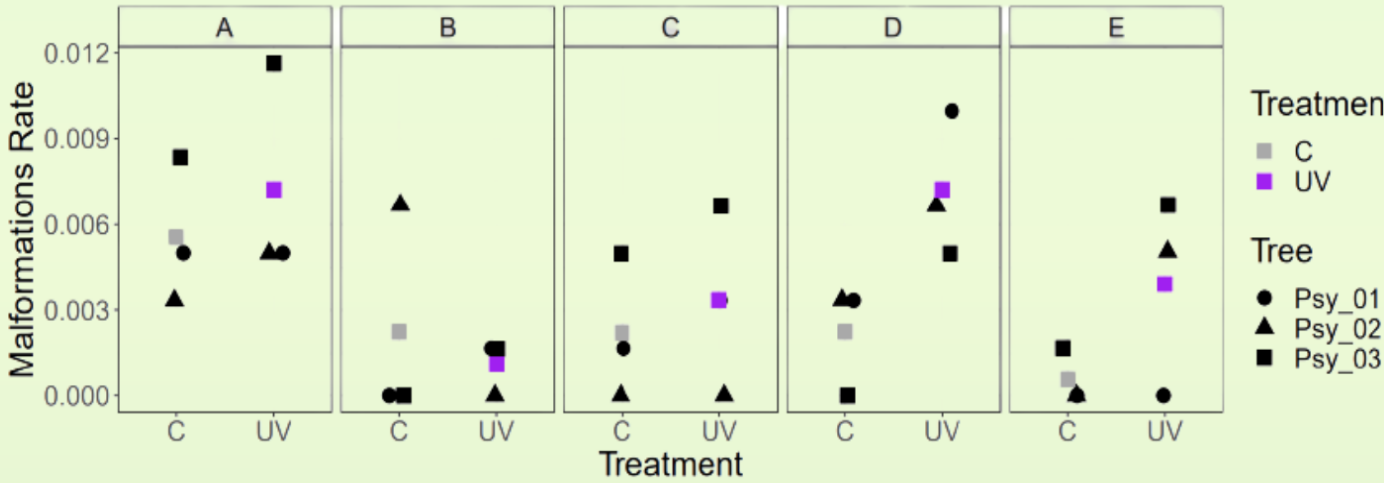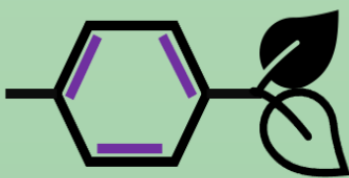
Future work

Fig 4 shows examples of abnormalities found in the experiment

During the analysis of the *P. sylvestris* pollen grains we also found unexpected abnormalies related to (i) under development and (ii) distorted exine walls (Fig 4).

These were not noted by Benca et al. and require further investigation.

References

Benca, J. P., Duijnstee, I. A. P., & Looy, C. V. (2018). UV-B–induced forest sterility: Implications of ozone shield failure in Earth's largest extinction. Science Advances, 4(2), e1700618. https://doi.org/10.1126/sciadv.1700618

Looy, C. V., Twitchett, R. J., Dilcher, D. L., Van Konijnenburg-Van Cittert, J. H. A., & Visscher, H. (2001). Life in the end-Permian dead zone. Proceedings of the National Academy of Sciences, 98(14), 7879–7883. https://doi.org/10.1073/pnas.131218098

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

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