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Effects of Polyethylene Microplastic and Nanoplastics Particles on Santa Monica Mountain Fern Gametophytes

Breanna Colunga
Dallas College

Thomas Vandergon
Pepperdine University

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Breanna L Colunga, Dallas College   Mentor: Dr. Thomas Vandergon

Introduction

Plastic is a convenient yet gruesome material. There are multiple types of plastics found within the world around us. These include polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polyvinyl chloride (PVC). [1] They can be divided into two groups: primary plastics which are manufactured at their current size, and secondary plastics which are broken down by physical strain, UV radiation, and other environmental factors. [1]
Secondary plastics, which are small and easily absorbed; micronized plastics, have been detected in seafood (fishes, shrimp, mussels), household products (sea salt, honey, sugar, plastic tea bags), tap water, bottled water, beer, construction sites, factories, and farmland. [1,2]
Ferns are thin haploid organisms, are exposed to all elements. Little know about the effects of plastics on plants. [3] Only one research paper studying a single fern called the *Ceratopteris pteridoides* (C-fern) has been published. [3]
In that study they found that a higher concentration of nano plastics caused a change in the shape, and number of rhizomes and a decrease in the hermaphroditic characteristics, and the growth rate was affected by the higher concentration of nano plastics. [3]
There have been no studies on any native fern populations examining the effects of micro- and nano-plastic particle exposure. This study aims to characterize whether exposure to different amounts of polyethylene micro/nano plastics affect the germination and development of fern gametophytes in the native ferns of the Santa Monica Mountains.

Question and Hypothesis

Question:

Does Exposure of Fern Spores and Gametophytes to Micro/Nano Polyethylene Particles Affect Germination and Development?

Hypothesis:

The Exposure of Fern Spores and Gametophytes to Micro/Nano Polyethylene Particles Will Affect Germination and Development.

Experimental Design and Materials

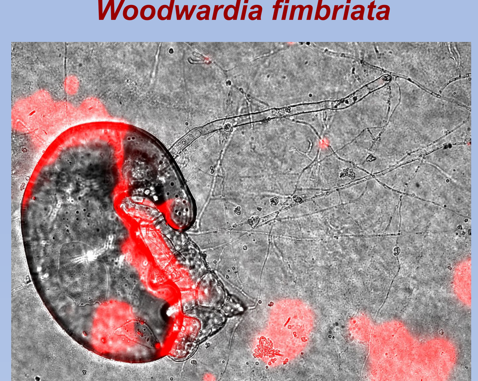
Spore wash: Tween 20,1% bleach, Bolds basal media, Distilled water

Figure 1: 1.5 ml Screw cap tube used to clean spores.

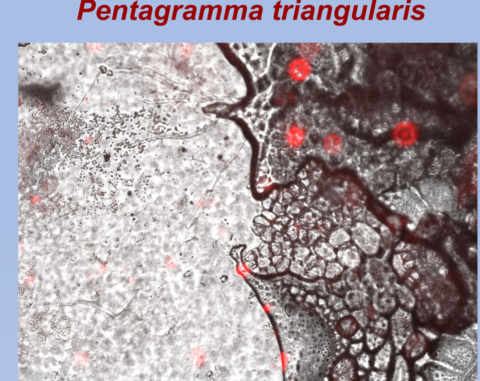
Figure 2: Plate set upfor spore seeding used or the experiment. Plate contained 1% agar in 0.705 g/L Bolds Basal Medium

Treatments
- PE beads (Cospherics, PENS-0.98) size 740 nm - 5.00µm
- Control No PE
- 20 ug/ml PE
- 40 ug/ml PE
- Pictures taken every week for a month

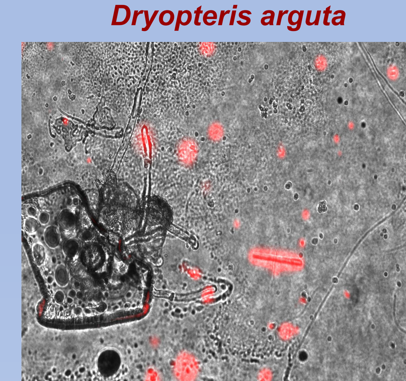
Woodwardia fimbriata



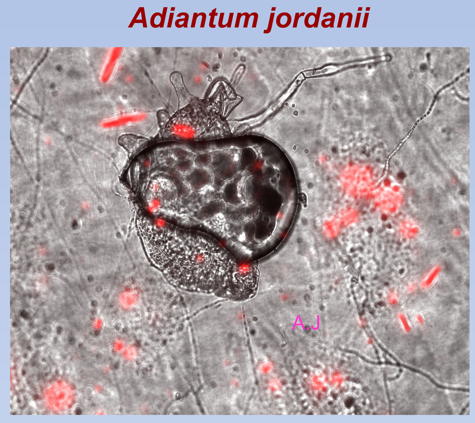
Pentagramma triangularis



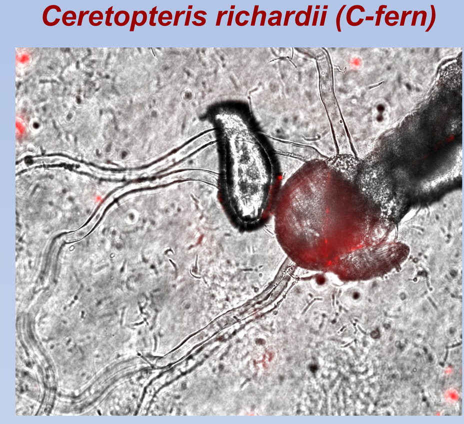
Dryopteris arguta



Adiantum jordanii



Ceretopteris richardii (C-fern)



Stain uptake:
- 40 ug/ml PE stained with Nile Red
- Fluorescent images taken two weeks after plating (Nikon)

Results

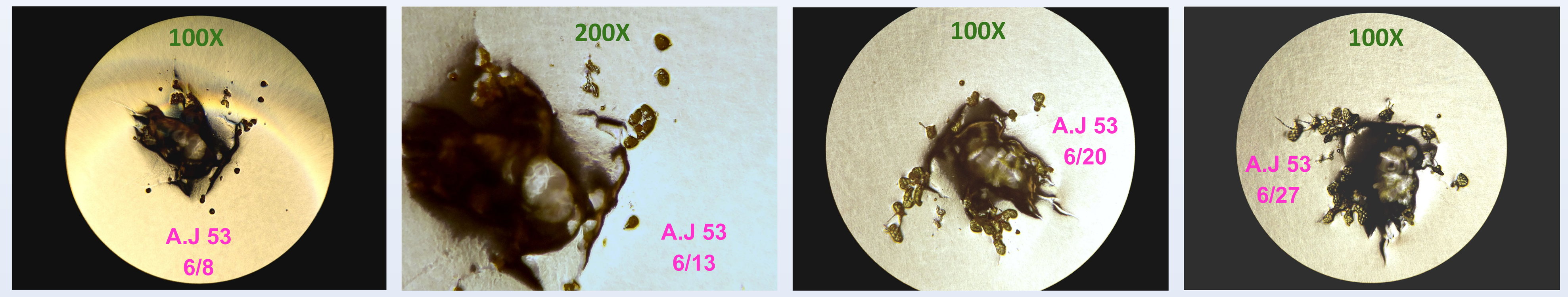


Figure 1: (ABOVE) Photographs showing *Adiantum jordanii* spore germination across three weeks.

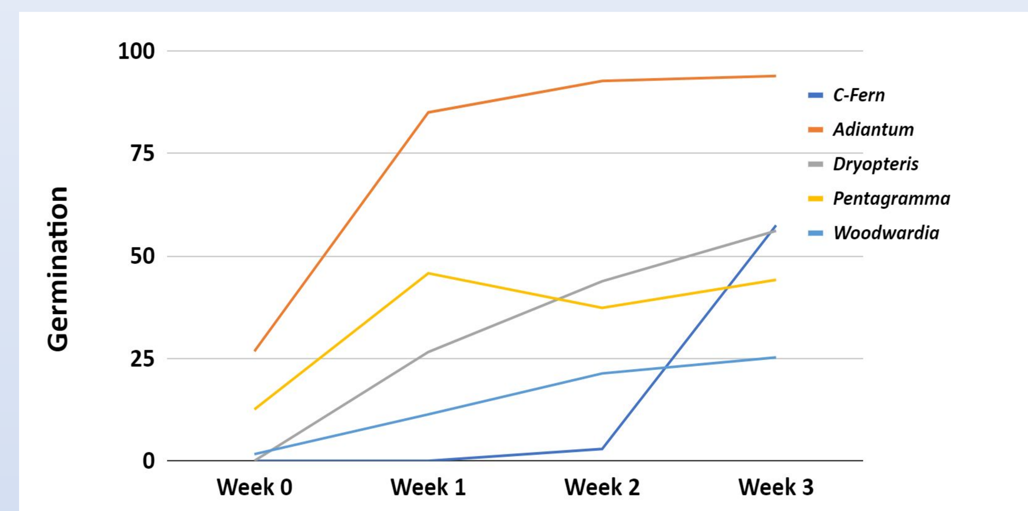
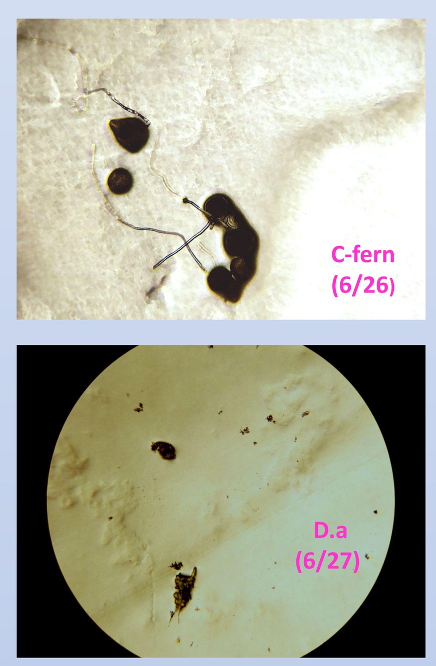
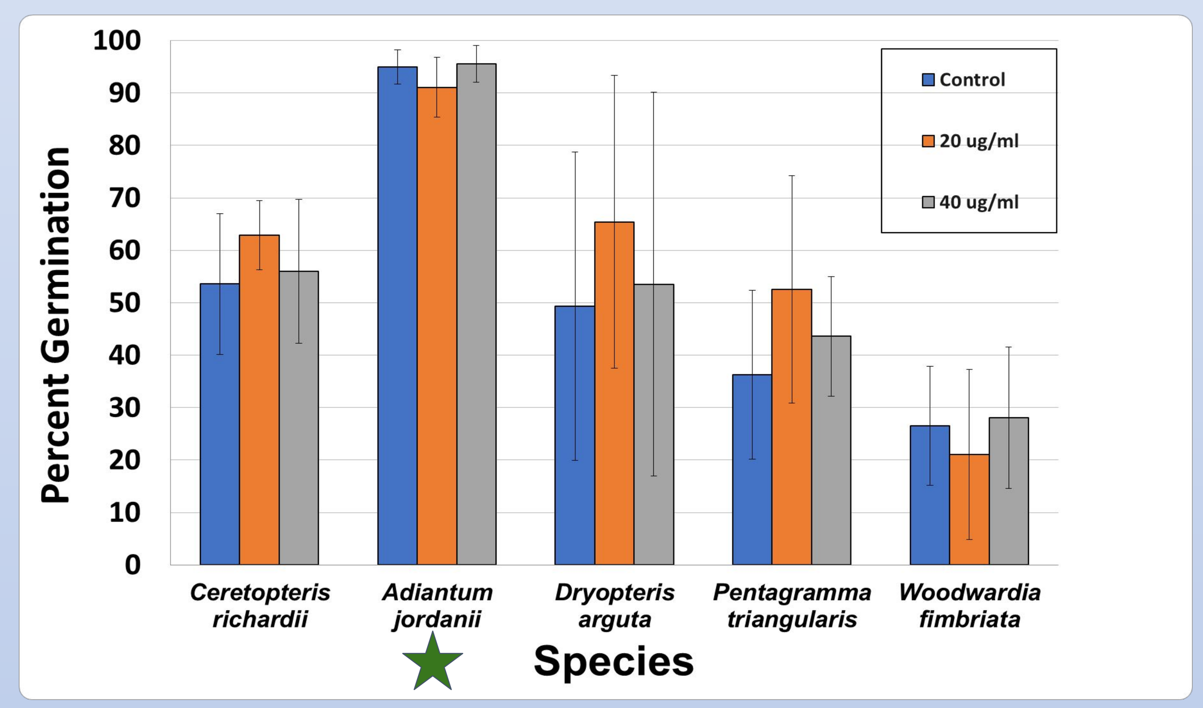


Figure 2: (LEFT) Graph showing the germination rate for each of five fern species across three weeks of growth.





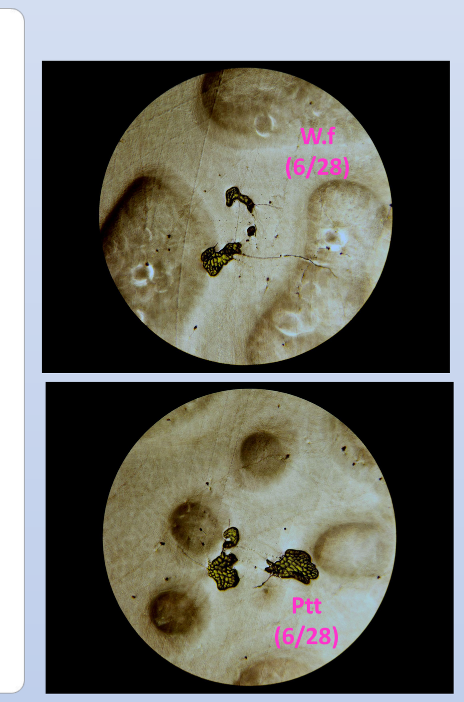
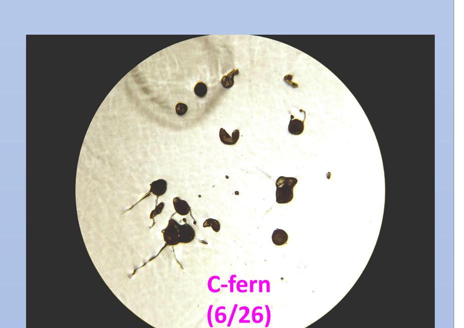
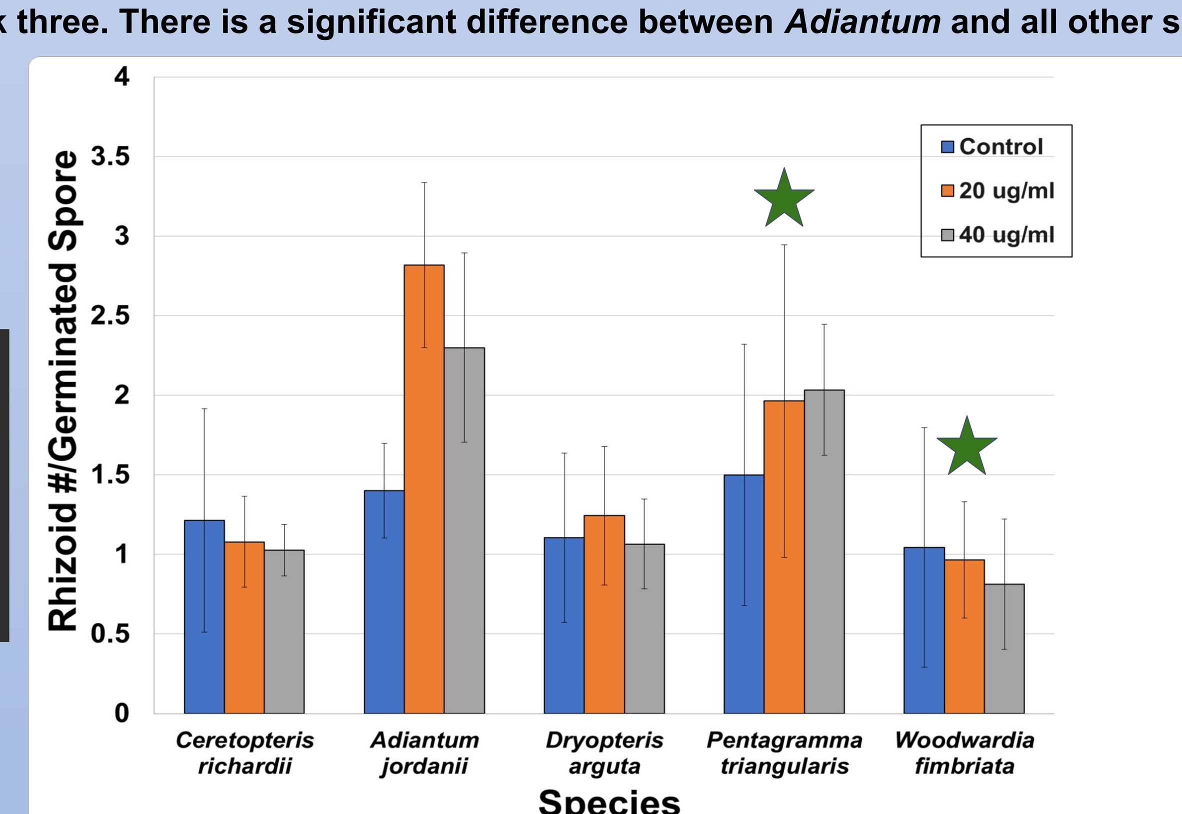


Figure 3: (ABOVE) Graph showing the percent germination for each of five fern species for week three. There is a significant difference between *Adiantum* and all other species.





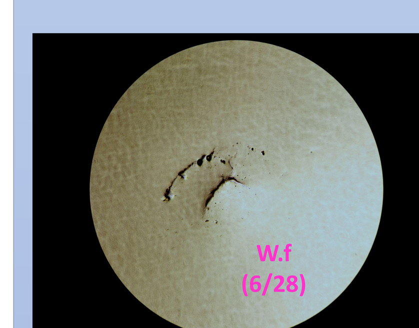


Figure 4: (ABOVE) Graph showing rhizoid number per germinated spore for the five fern species on week three. There is a significant difference between *Pentagramma* and *Woodwardia* marked by a star.

Three species show a consistent downward trend with increasing plastic concentration.

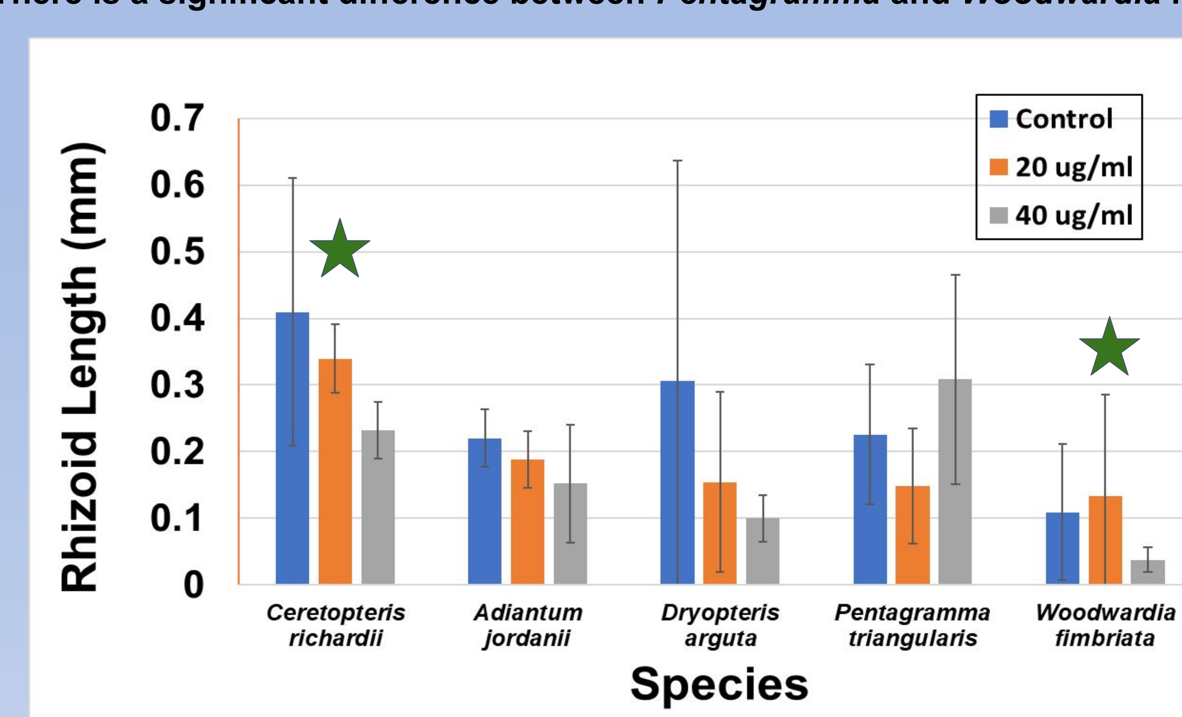


Figure 5: (ABOVE) Graph showing rhizoid length for each of the five species on week three. There is a significant difference between *C-fern* and *Woodwardia,* Which is marked by stars.

Abstract

Plastics are found throughout our environment, both as secondary and primary forms. A handful of papers have mentioned that plastics can be found in our water sources and soil. Plastics are used in almost everything we use. In one study, it was shown that Polyethylene (PE) is mainly used in packaging, and it was found to be the most widely used plastic. There is no escape for humans, plants, or animals from the presence of plastics. Although there have been a few studies on plants, particularly agricultural crops, surprisingly, only one study has been conducted on the fern called Ceratopteris (C-fern). In the experiment I tracked the germination percentage, rhizoid length, and rhizoid number in five species: ***Woodwardia fimbriata, Dryopteris arguta, Adiantum jordanii, C-fern, and Pentagramma triangularis***. While we could observe a trend in the data that followed the previous research paper done with polystyrene, we are unable to conclude that there is a significant difference in treatment. We did see a significant difference between the species.

Conclusions

- **Polyethylene micro- and nanoplastics appear to attach to spore casings but in general do not attach to rhizoids.**
- ***Adiantum* spores had significantly higher germination rate than all other species**
- **There is a trend in smaller rhizoid length as plastic concentration increases for most species.**

Acknowledgements

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