An investigation into the effect of hair on the growth of *Elodea canadensis*

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Proposal

A study into the growth of the water plant *Elodea* will be carried out so as to ascertain the effect of hair on growth and note any other observations.

Executive summary

In a study across 123 days the differences in growth of 3 separate, identical, cuttings of a plant identified as *Elodea Canadensis* were measured in relation to their proximity to hair. One subject was kept in a tank without hair (tank one), one subject placed directly onto a ball of hair, and a second was grown adjacent to the ball of hair in the same tank (tank two).

The plant grown on hair had the most total growth with 591.6% increase from its original 12cm length and showed the most visible root growth. The hair-adjacent subject showed a total growth of 558.3% of its original 12cm length and had visible root growth towards the hair. The non-hair subject showed total growth of 250% of its original 12cm length and had no visible root growth.

Other notable observations were that the water clarity in the non-hair tank was poor compared to the tank containing hair and that the hair tank showed significantly more biological activity during the study including patterns on the glass and visibly moving detritus worms.

Background

Through my work with Matter of Trust I was aware of how hair influenced plant growth based on a research project run in the Atacama Desert in Chile (reference 1) and the San Francisco Presidio Trust soil remediation project (reference 2). Hair is present in most ecosystems in quiet cycles (through moult and mortality) and I was curious as to its effects on aquatic plants. I am also aware of the results due to be published from a study conducted by the University of Sydney into the effects of hair on the physico-chemical characteristics of surrounding water which has produced preliminary data showing there to be negligible impact (reference 3)

As a precursor to this study, I did two things; I placed a small ball of human hair into a domestic fish tank (with two fantail fish, shoots of a plant identified as Elodea Canadensis and a plant of unknown genus) and I placed a scrim of felted human hair adjacent to a *ca.*50cm^2 patch of seagrass on a beach to observe any effects.
In the fish tank the plant sent out roots and moved visibly towards the hair. As the fish pecked the hair and dispersed it, the plants continued to send out new roots to re-anchor to the hair before eventually the hair dispersed and the plant lost anchorage and growth lessened. (Image 1)
With the felted hair scrim in the natural environment, various seaweed species were observed to anchor to it and a seagrass plant was growing on it. If the seagrass grew from seed or rhizome growth is unknown (Image 2)

Plants from the Elodea and Egeria genera are known for their ready proliferation from simple cuttings in a wide variety of physico-chemical water conditions and as such would make a suitable test subject for rate-of-growth study in indoor tanks.

Proposed methodology

The effects of hair upon aquatic plant growth appear to be unobserved, so the primary objective is to design an initial study visually assessing differences in plant growth over a set period of time in reference to the plants being able to set root in hair.

Two 12L capacity fish tanks will be marked with a 1cm graduated scale to aid observation and filled with a 2:1 volume ratio of tap water: water removed from an established fish tank. Three genetically identical 12cm plant cuttings of a plant identified as Elodea Canadensis will be taken and set out for observation as follows:

- Tank one will contain one plant is on its own with no other inputs, anchored in gravel substrate (ca.2-3mm grain size).
- Tank two will contain one plant is wrapped at the base in ca.3grams of human hair, anchored in gravel substrate (ca.2-3mm grain size) and a second plant anchored in gravel substrate adjacent to the plant wrapped in hair. The two plants in tank two will be clearly separated and a dividing centre line drawn on the tank.

The two tanks will be left at ambient room temperature for a period of 4 months (June-October), in a north facing window with bright, but not direct, sunlight. Anticipated temperature range of ca.15C-25C, approximately 10 hours of daylight exposure per day.

The tanks will then be left and observed, water levels will be monitored and topped up with tap water if required. Growth can be visibly measured until plant growth reach the water's surface and then at the end of the four-month period the plants will be removed from the tanks and final growth measurements taken for comparison.

Alongside the primary objective of measuring plant growth, other observations such as algal growth, water clarity, proliferation of other aquatic life and the emergence of shoots and roots from plants will be noted and photographed.

Controls

Whilst the two tanks are slightly different dimensions, they are both of the same volume capacity and will be filled with waters from identical sources. Sunlight exposure, air and water temperature will not be controlled but as tanks will be situated adjacent to each other conditions are presumed to be effectively identical. Plant cuttings will all come from the same mother plant meaning genetics are identical and cuttings will all initially be 12cm of stem and foliage – none of the plants will have existing root growth prior to their introduction into the study tanks.

Results

Two 12L capacity tanks were each filled with ca.9L of tap water and ca.3L of water taken from an established fish tank. Three 12cm cuttings were taken from a single mother plant identified as Elodea Canadensis and set up in the two tanks prepared with a 1cm graduated scale, to aid observation, and ca.50g per cutting of ca.2-3mm gravel substrate to anchor the plants and simplify the process of growth measurement.

One plant was anchored in the substrate in tank one, with no further modification. A second plant had the base of its stem wrapped in a ball of ca.3g of human hair and was anchored in the substrate of tank two, while the third plant was anchored in the substrate of tank two adjacent to the plant wrapped in hair but separated by ca.9cm. (Image 3).

The tanks were then left side-by-side in front of a north-facing window on 28th June 2023. All growth measurements given include the original 12cm length of the cutting.

The growth of the three plants was monitored and recorded every 3-4 days (Images 4-5) for the first 15 days of the study, at which point the plants had reached a height where they broke the surface of the water and so accurate visual measurement ended until a final measurement at the conclusion of the observation (Dataset 1).

For the first seven days of growth all three samples grew in a consistent manner. The non-hair and hair adjacent samples often had identical growth with the sample directly on hair having slightly less growth until the time period between days 7-11 (5th-9th July 2023) when a surge of growth in the plant directly on hair overtook the other plants.

On 28th October 2023, after 123 days of growth, the three plants were carefully removed from their tanks taking care not to damage root growth. The plant grown directly on hair was removed from the ball of hair. The total growth of the three plants was measured from the base of their stems to the tip of their main shoots, the number and length of any side-shoots was also measured and recorded. (Data set 2) (image 6)

The main shoot of the plant grown directly on hair reached a final length of 45cm, the hair-adjacent plant grew to 24cm and the non-hair grew to 21cm. The final measurement of the non-hair subject was actually 1cm less than the previous visual measurement which could be attributed to the inaccuracy of the visual measurement or due to plant shrinkage (which can be an indicator of poor plant health).

Side-shoots were seen to sprout on the non-hair and hair-adjacent plants at the same time after 30 days of growth but shoots on the directly on hair sample did not begin to grow until after 45 days of growth. After 123 days of growth the non-hair subject produced only one shoot that reached a total length of 9cm, the plant grown directly on hair had two shoots of 21cm and 5cm (a total of 26cm) and the hair-adjacent plant produced five shoots of 6cm, 7cm, 9cm, 10cm and 11cm respectively (a total of 43cm).

During the first 60 days the two tanks were seen to be visually identical and growth was the only observation. During the third month differences between the tanks regarding algae growth and water quality started to become notable. In the non-hair tank water clarity became poor and looking onto surface of the water in the tank a film had formed making it somewhat opaque. (Image 7) Globular clumps of brownish algae formed and red, black and brown algae formed on the glass and died off in succession leaving clear patches after their decay (Image 8). The hair tank had good water clarity, no globular clumps of algae or film on its surface but did have a slight green hue to the water. The glass on tank two (containing the two samples, one on hair one hair-adjacent) had a pattern of green algae growth which grew prolifically and was in stark contract visually to tank one (image 9). The algae patterns are best described as reminiscent of Turing patterns (reference 3-4) in that they repeat but not perfectly (Image 10).

When looking closely at the tank with the hair, large numbers of detritus worms (*Naididae*) could be seen moving energetically and over course of the second half of the study many of the detritus

worms grew to ca.3-5mm in length. So many detritus worms were present they formed a tide line (Image 11). The non hair tank did not have visibly moving detritus worms or green algae forming patterns.

After 123 days of growth there was no visible root growth on the non-hair subject. The plant grown directly on hair grew roots into the hair some of which broke away when removing the hair (Image 12). The hair-adjacent sample grew roots and this was visibly towards the hair sample (Image 13).

In summary

The plant grown directly on hair had the most growth with a main shoot growth of 45cm after 123 days and two shoots with total growth of 26cm, giving a sum total growth of 71cm. The main shoot grew to 375% of the original 12cm cutting and the sum total growth was 591.6% of the original cutting.

After 123 days the plant grown adjacent to the hair had a main shoot growth of 24cm and five shoots with a total growth of 33cm, giving a sum total growth of 67cm. The main shoot grew to 200% of the original 12cm cutting length and the sum total was 558.3% of the original cutting.

The non-hair plant had a main shoot growth of 21cm after 123 days and one side-shoot with a length of 9cm, giving a sum total growth of 30cm. The main shoot grew to 175% of its original cutting length and the sum total growth was 250% of the original cutting length.

References:

1: Carenini, M. 2022, Matter of Trust Chile. https://matteroftrust.org/wp-content/uploads/2022/08/Hair-mats-can-increase-production-.pdf

2: Stuart B. Weiss, Ph.D. Creekside Science Lewis Stringer Presidio Trust October 2021 https://matteroftrust.org/presidio-trust/

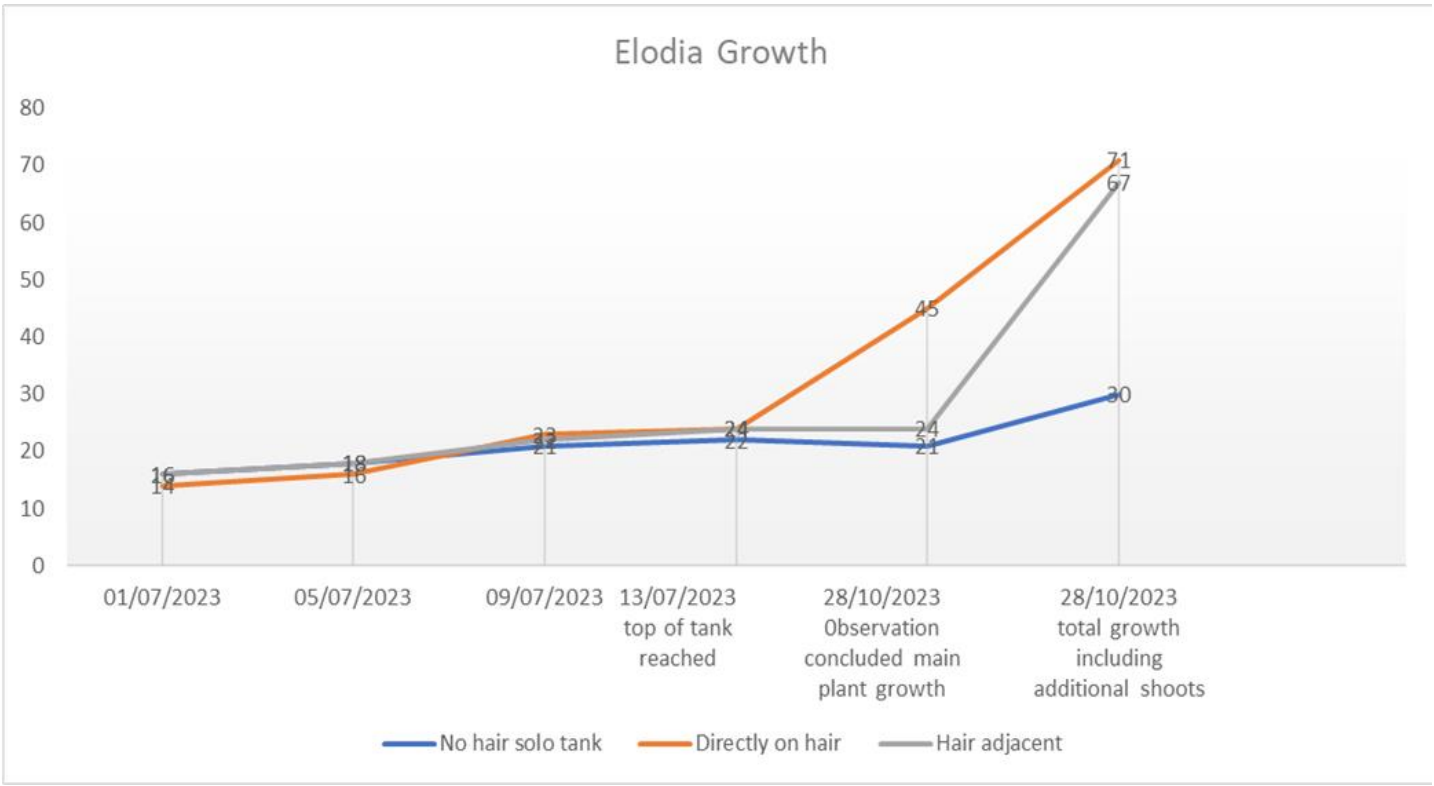
3: Dr M Murray. “The Influence of Recycled Waste Stream Fibres on Water Quality Indicators”. To be published by Springer Nature Paper and research submission accepted for the International Sustainability Conference.

4: B. D'Aquino. “Studying Turing Patterns in Vegetation”. American Physical Society meeting, Las Vegas, March 7, 2023. https://meetings.aps.org/Meeting/MAR23/Session/F46.3

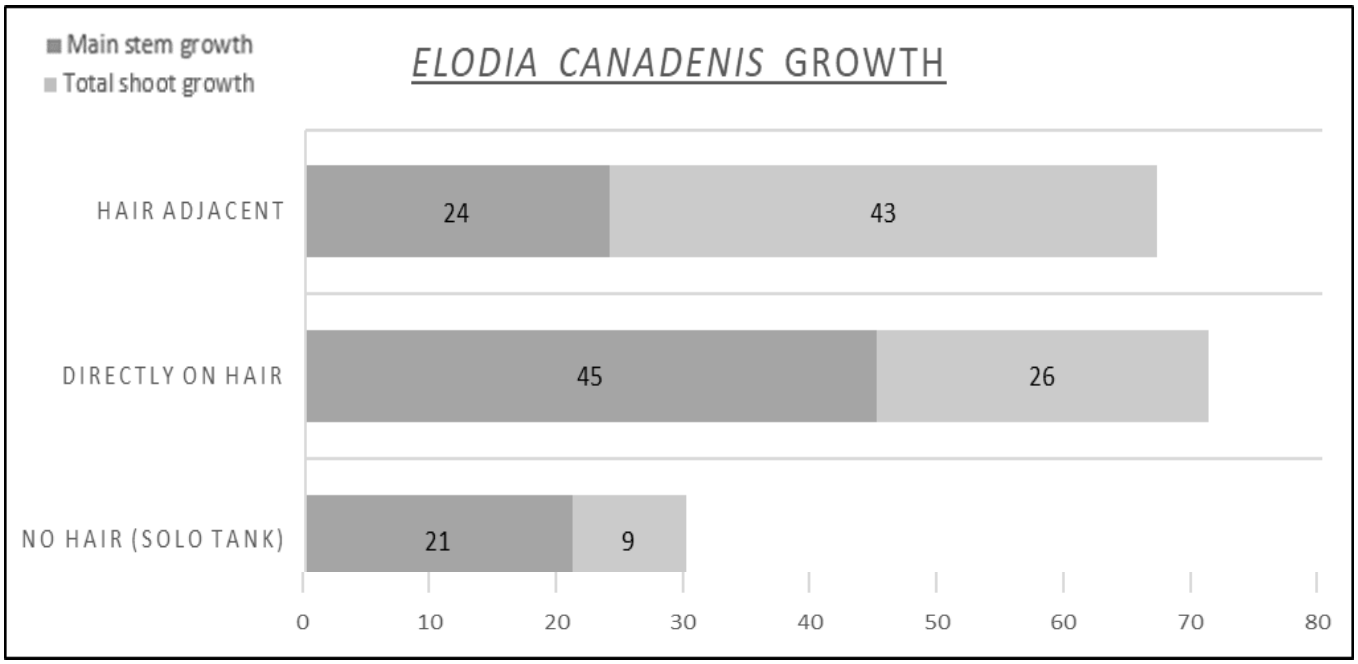
5: James R. Riordan. www.sciencenews.org, 2023. https://www.sciencenews.org/article/seeds-alan-turing-patterns-nature-math

Dataset 1

		Date of observation (days of growth)					
		28/06/2023 (0)	01/07/2023 (3)	05/07/2023 (7)	09/07/2023 (11)	13/07/2023 (15)	28/10/2023 (123)
Height of main shoot (cm)	No hair, solo tank	12	16	18	21	22	21
	Directly on hair	12	14	16	23	24	45
	Hair adjacent	12	16	18	22	24	24



Data set 2.



	No hair solo tank	Directly on hair	Adjacent to hair
Main plant	21	45	24
1st Shoot	9	21	11
2nd shoot	0	5	10
3rd shoot	0	0	9
4th shoot	0	0	7
5th shoot	0	0	6
Total Shoot growth	9	26	33
Total plant growth including shoot growth	30	71	67
Total growth minus 12cm start growth	18	59	55

Image 1

Background investigation into the effect of hair on an established fish tank.

Top image: plants gravitating towards hair including plant of unknown genus sending out black roots (bottom right of top image).

Bottom right: Elodia root growth into hair.

Bottom left: Elodia floating free after the complete dispersal of hair (over the course of several weeks) by two fantail fish (pictured) root growth still evident.

Image 2

Background investigation into the effect of hair on seagrass and seaweed growth in the natural environment.

Image 3

Initial plant cuttings (top) and setup at Day 0 of the study showing tank one (bottom-left) and tank two (bottom-right).

Image 4

Tank one after 11 days of growth.

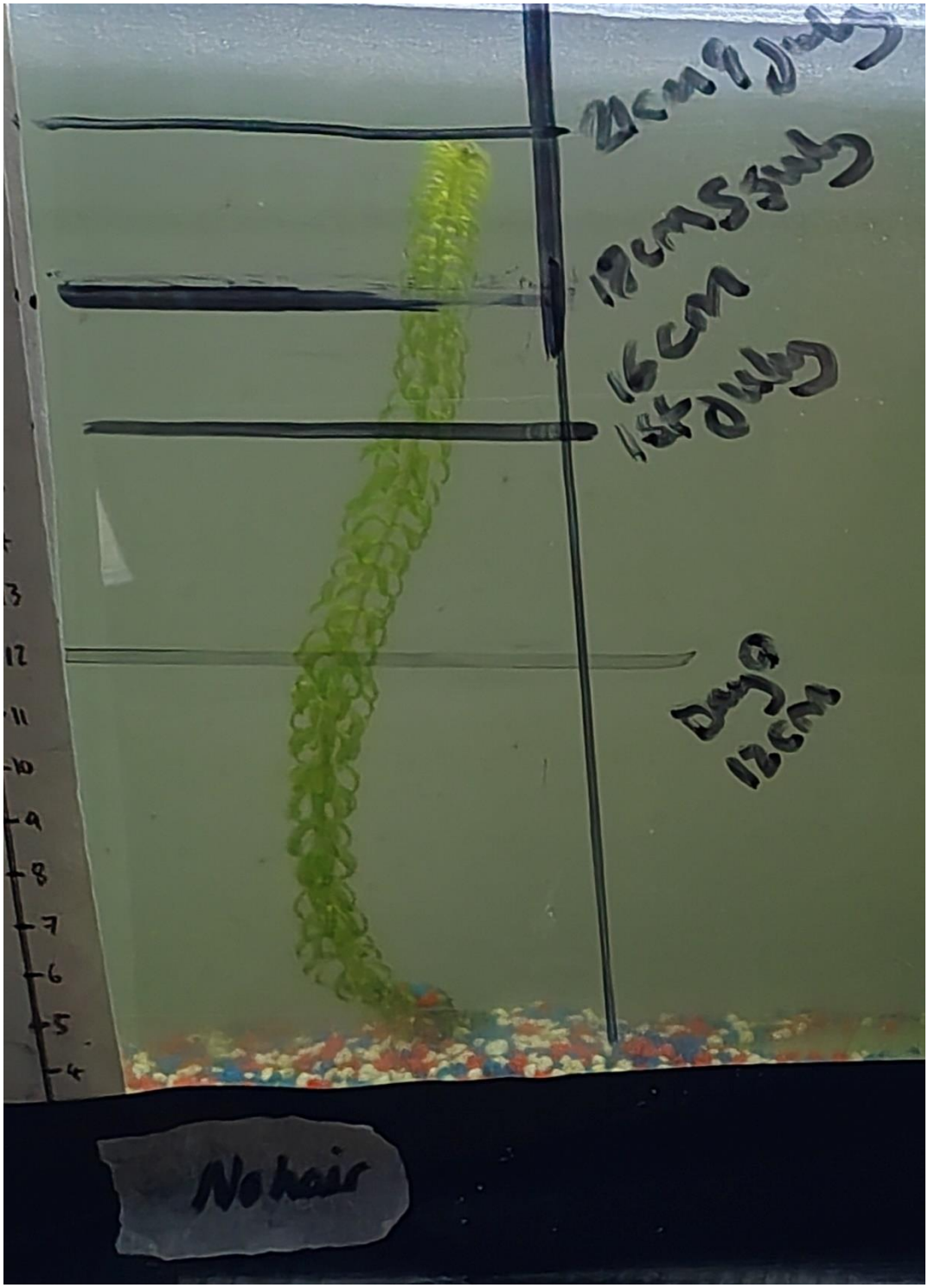


Image 5

Tank 2 after 11 days of growth.

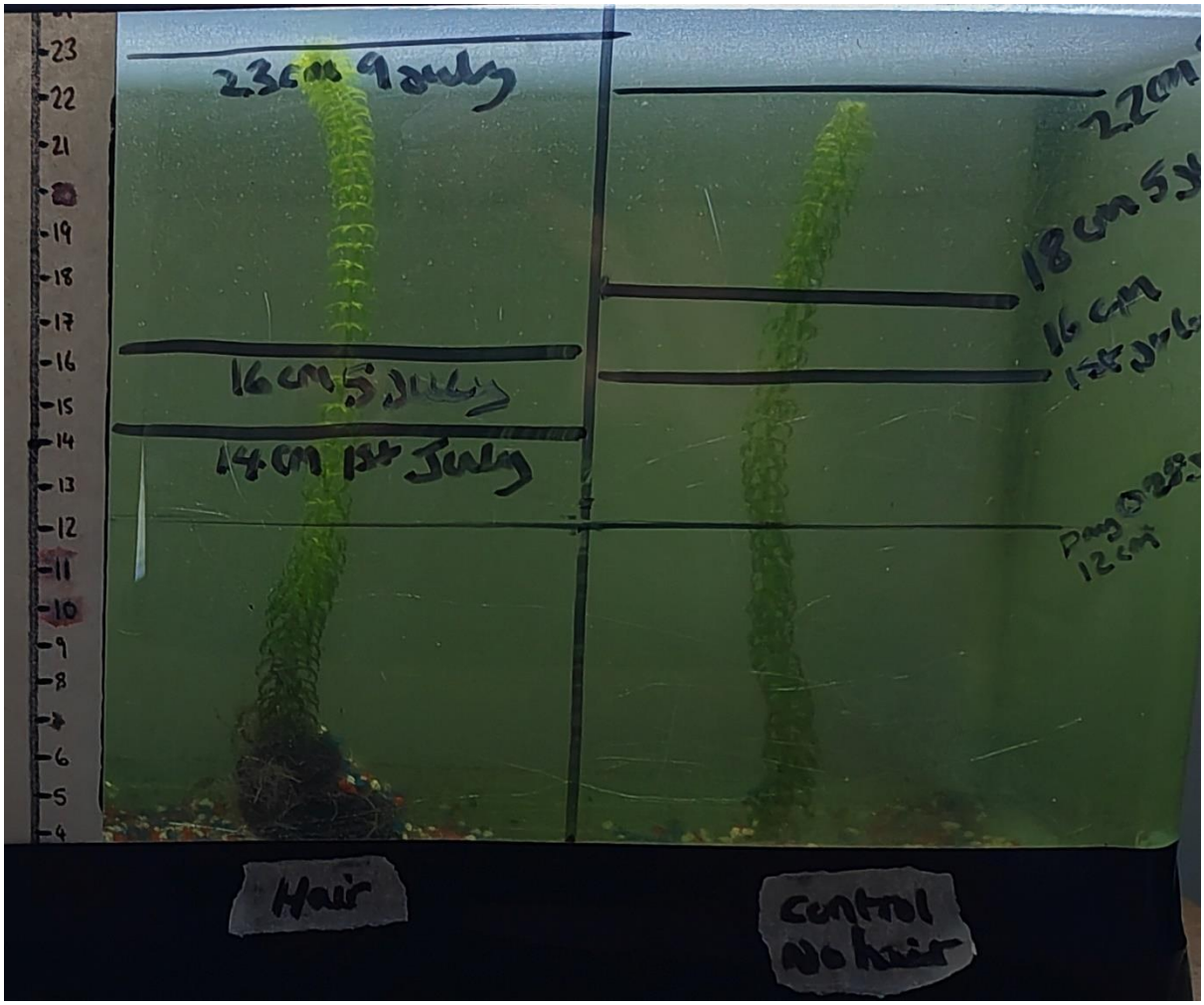


Image 6

Comparative image of all three cuttings after 123 days of growth.

Image 7

Comparison of water quality from above.

Left: Tank one (no hair) film on water making it slightly opaque with globular, floating algae growths.

Right: Tank two (hair) good clarity, no globular floating algae slight green hue to water.

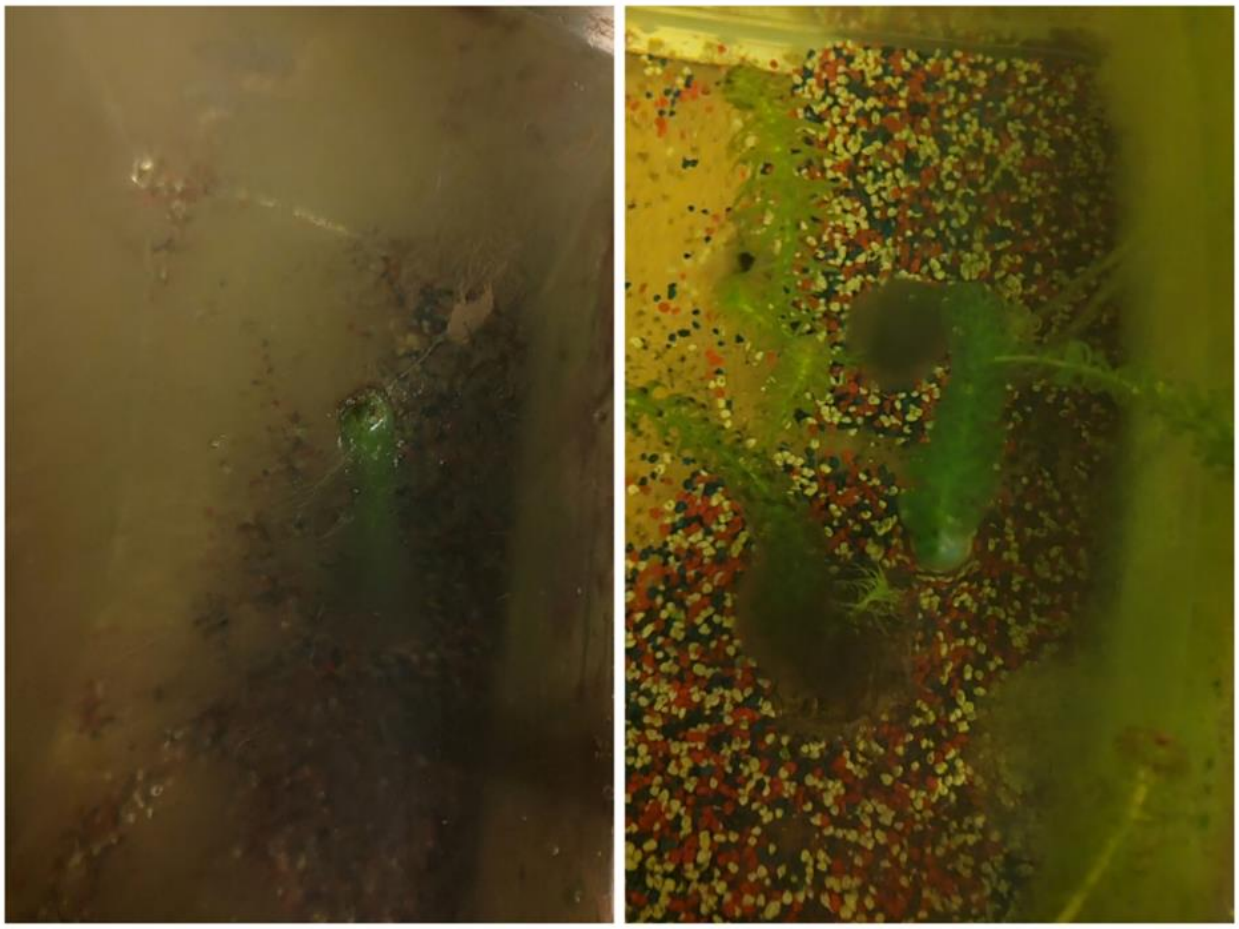


Image 8

Tank One red, green, brown and black algae and die off pattern visible top right.

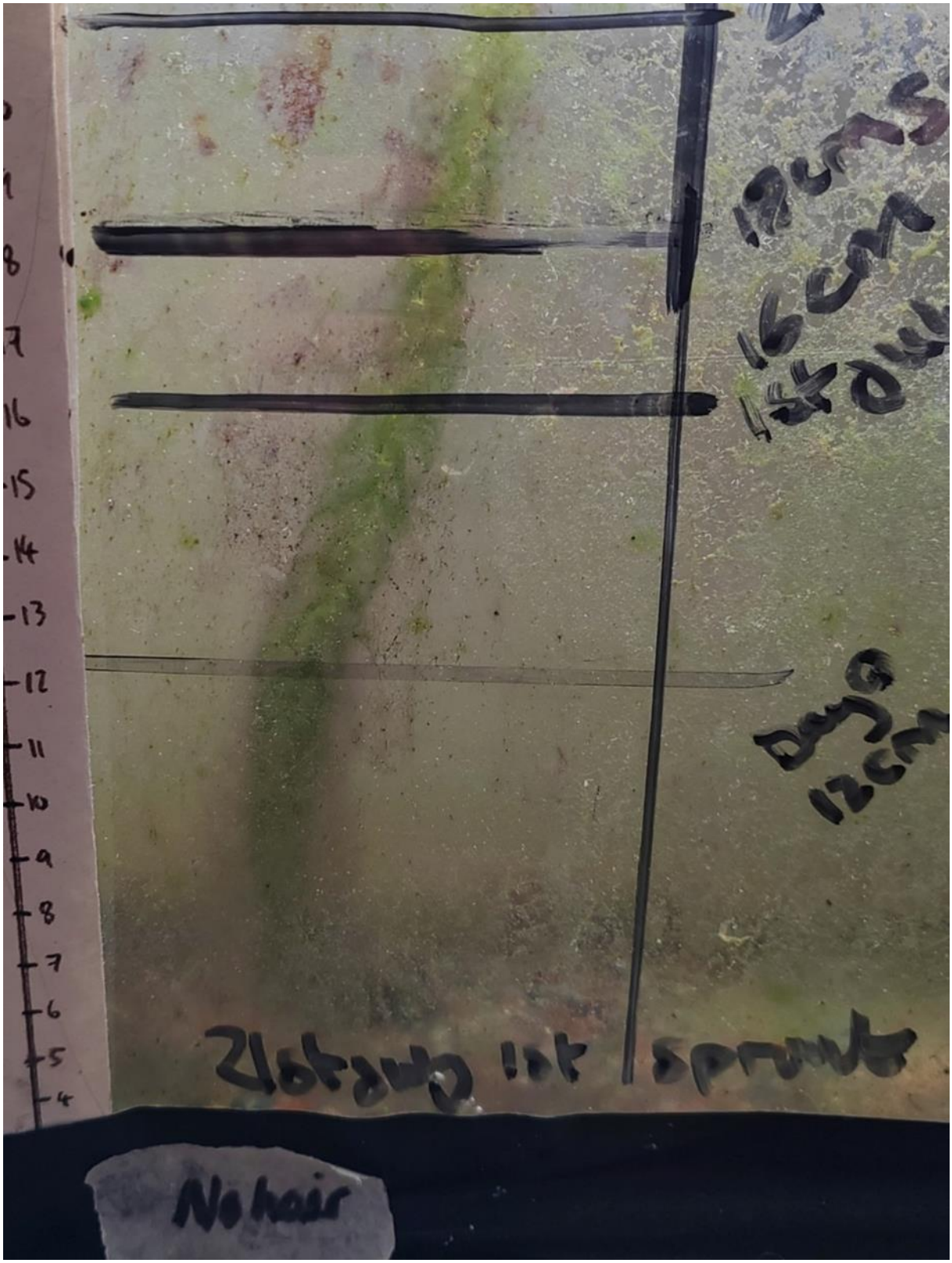


Image 9

Visual comparison between tank 2, hair tank (above) and tank 1, no hair (below)

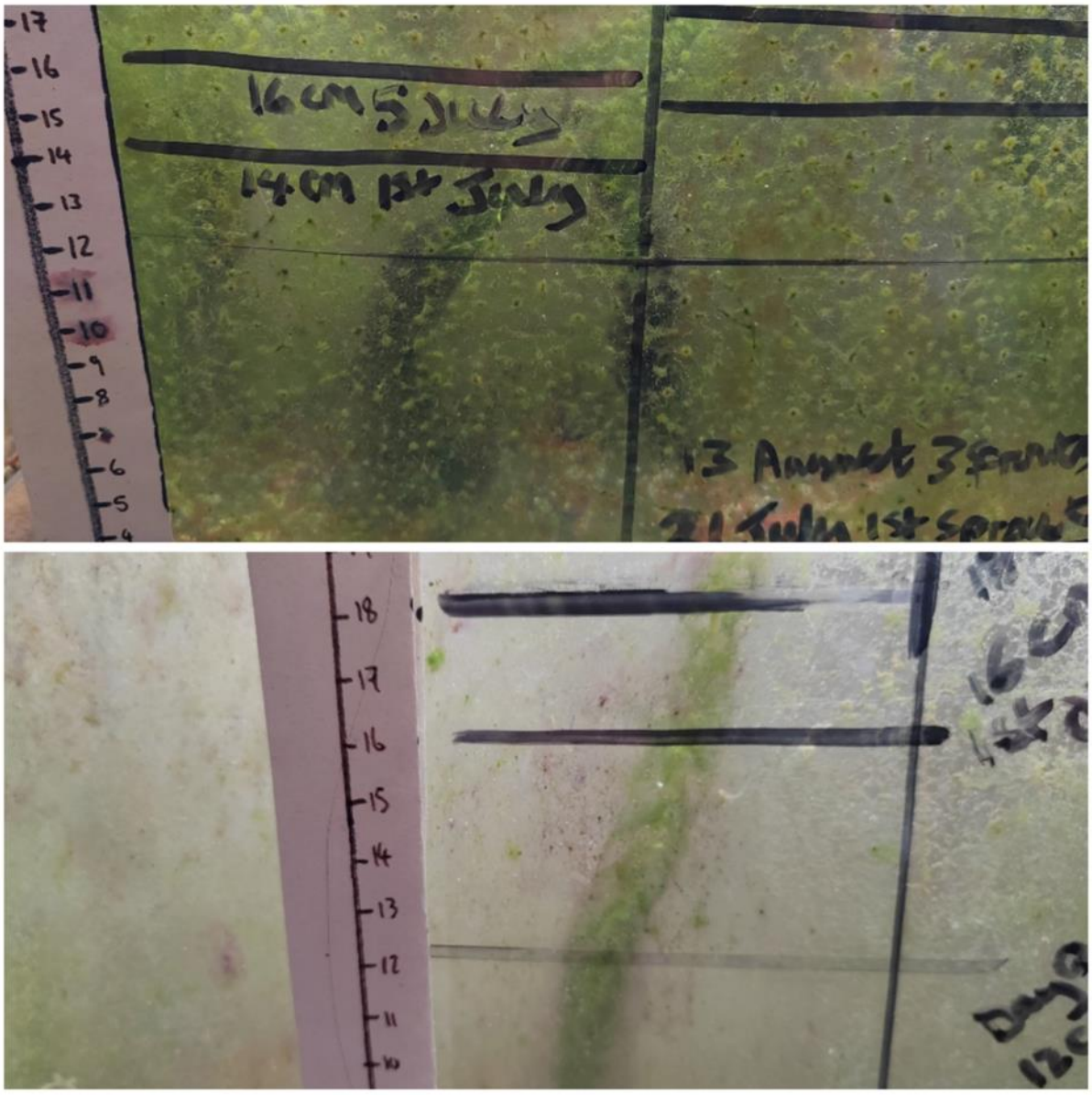


Image 10

Tank 2, Patterns in green algae comparable to Turing patterns.

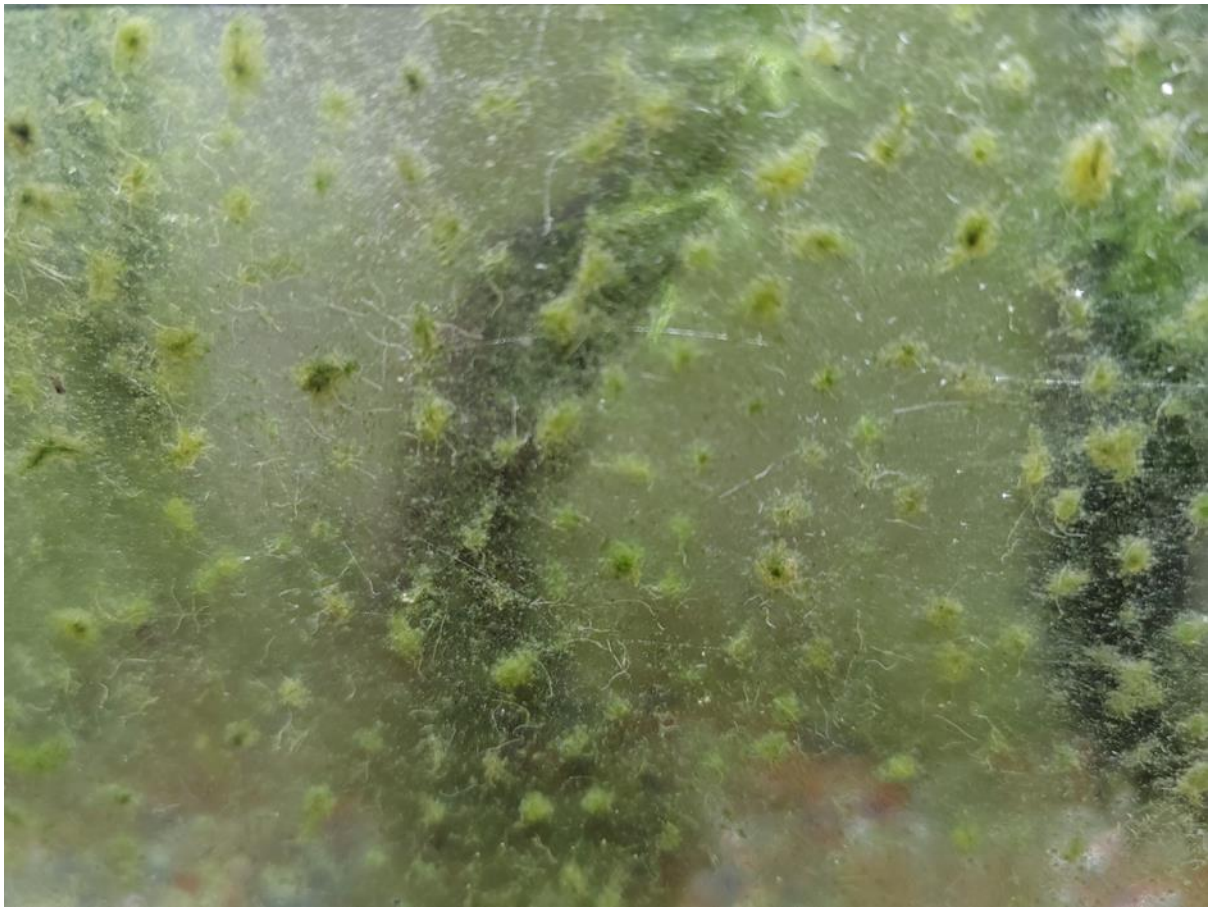


Image 11

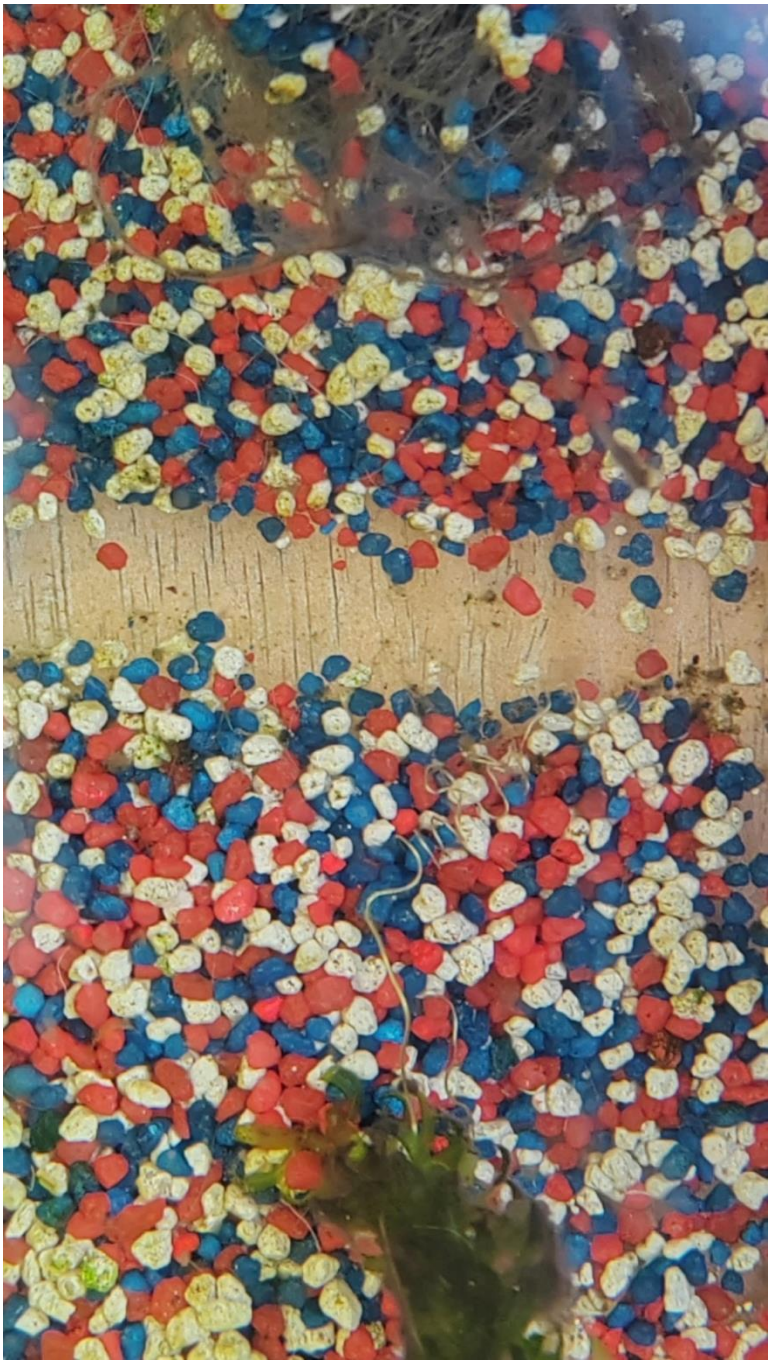
Detritus worms forming a tide line in tank 2.

Image 12

Comparative image of root growth across all three samples.

Image 13

Ariel shot into tank 2, showing root growth extending from hair-adjacent towards the on-hair sample.



Further study proposals

Hair as a substrate for seagrass in comparison to hessian and coir which are non-native to many places they are being piloted. While Seawilding (Scotland's first community-led seagrass project) did some tentative trials, results have not been formally presented as yet. Further study is justified including in university wave simulators alongside other substrates.

Aquatic interactions with hair are unknown. While we know some of the interactions with terrestrial life surrounding hair (pollinators such as moths are attracted, ground insects deterred, mammals through moult and mortality shed hair, birds disperse hair through rooting and via use for nesting) I can find no record of knowledge on aquatic interactions. Does hair deter some species such as crabs and lugworms (which predate aquatic plants) and attract others? Do fish disperse hair from marine mammal mortality as demonstrated with a ball of hair in the preliminary established tank observation? Seals are a marine mammal with a high mortality which often end up in the intertidal zone. A seal fall project could shed light on biological interactions in the field.

Patterns in growth observed here and also with mycelium fruiting in the Presidio Trust's work fit into the concept of Turing patterns but also into the newly proposed law of increasing functionality. I would postulate that hair, as well as feathers and scales (which all share similar compositions), are more relevant in ecosystems than realised and can catalyse microbiology and plant growth in ways not yet studied. This could be especially important as they seem to restart growth cycles after decay so could aid restoration of various ecosystems through bio mimicry - something vitally needed and in its infancy of standard operating procedures (currently often dependant on non-native products).

A study of effects of feathers on the growth of aquatic plants in saltwater could make the link between bird migration aiding aquatic ecosystems. Do feathers aid growth as hair does?

Why the plants grow more in the presence of hair is unknown, are they directly feeding on the hair itself or is there a symbiosis with microbial life forming on and processing the hair?