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A2 Biology coursework

AN INVESTIGATION INTO THE EFFECT OF WAVE EXPOSURE ON THE MORPHOLOGY OF *FUCUS VESICULOSUS* (BLADDER WRACK)

Introduction

This investigation is on the effect of wave exposure on the morphology of the seaweed *Fucus vesiculosus*, commonly known as bladder wrack.

Fucus vesiculosus is a common seaweed, found in the Atlantic, which is made up of a holdfast, midrib and fronds. It also has bladders to aid buoyancy so that the plant can float on the surface of the water and get light for photosynthesis. Photosynthesis is not only used for growth, but also for the development of the holdfast, which uses carbohydrates not used up in the synthesis of starch.

From a previous pilot study of a transect along a rocky shoreline, it is known that *Fucus vesiculosus* always grows on the mid zone of rocky shores (see appendix). This is because the water levels are too high on the lower shore, and the desiccation risk on the upper shore is too high.

At sites with high wave exposure, the shore is exposed to a lot of wave action and, there will be a lot of turbulence. Because of the turbulence, less light will be able to penetrate the water. The growth of the *Fucus vesiculosus* depends on carbohydrates being produced as a product of photosynthesis, and the rate of photosynthesis is directly proportional to light intensity. I know that at low light intensity, the chloroplasts are displaced, and therefore cannot perform their vital role in photosynthesis.

For this reason, brown seaweeds such as Fucus vesiculosus contains the photosynthetic pigment fucoxanthin, as well as chlorophyll a and b, which is required when light intensity gets low (i.e. when the tide covers the mid zone), as the water reflects a lot of light. It absorbs certain frequencies of light, from the blue end of the spectrum, which are available at the depth at which the plant is growing.

The *Fucus vesiculosus* plants get nearer to the surface of the water at highly exposed shores, due to turbulence, and so need less air bladders to get them to the surface. Air bladders are still present because, also due to the turbulence, sediment from the seabed may get disturbed, and settle on top of the *Fucus vesiculosus*, blocking its light. Therefore seaweeds growing at less exposed sites will have more air bladders, and subsequently, due to more photosynthesis, will be longer.

Genetic material of *Fucus vesiculosus* is similar, whatever the wave exposure, which means any differences between the seaweed found at the two sites, will be down to environmental factors.

Hypothesis:
There will be a higher number of air bladders on the *F. vesiculosus* at Instow because low wave exposure will encourage the formation of air bladders so the plants can float and get light to photosynthesise. This will mean that the plants will also be longer, due to more photosynthesis, and less rough conditions, which may rip the plant away from its holdfast.

Null hypothesis:
There will be no relationship between the wave exposure, and length and number of bladders on the *F. vesiculosus.*

Results

	ABBOTSHAM	INSTOW
Temperature (c)	21.8	22.9
Wind speed (m/s)	6	3
Salinity	33	34
PH	8.4	8.4
Relative humidity (%)	91	90

Table 1

Results table 1 shows the abiotic factors at the two sites, which have the potential to affect the investigation, if dissimilar to each other.

The no. of air bladders and the lengths of *Fucus Vesiculosus* at Instow and Abbotsham

Abbotsham		Instow	
Length (cm)	No. of air bladders	Length (cm)	No. of air bladders
30.5	1	36.5	14
28	2	18.1	15
30.5	4	15	10
30	11	21.3	12
39.5	9	15	13
32	0	17.5	17
45	5	14.3	16
18	4	16.7	10
43	5	26.5	29
25	4	21	19
36	6	19.6	7
31	4	17.3	12
46	5	16.5	8
54	2	32.5	14
33	3	23.3	17
42	4	39.5	7
46	5	27.2	27
28	3	32.5	21
34	7	32.5	20
25	2	24	16
21	4	20.1	17
28	5	20	17
34	3	22.5	9
32	4	28.5	21
40	7	38.4	20
42	6	37.3	17
33	4	27.6	21
48	5	16	13
29	2	9.3	5
26	3	11.3	3

Table 2

See graphs 1,2,and 3 for graphic representation of table 2.

From the results, a running mean was calculated and a graph plotted of the lengths of the plants at Instow, to make sure that an optimum sample number has been obtained, to prove that the results are a good representation of the whole shore.

The running mean is obtained by calculating the mean cumulatively.

(n1 + n2) / 2 = nn1

(nn1 + n3) /2 = nn2

(nn2 + n4) /2 = nn3 etc.

The running mean of lengths of *Fucus vesiculosus* at Instow

Sample number	Lengths (cm)
1	
2	27.3
3	23.2
4	22.7
5	21.2
6	20.6
7	19.7
8	20.1
9	20.2
10	20.1
11	19.9
12	20.3
13	20.5
14	21.4
15	21.5
16	21.6
17	22.6
18	22.9
19	23.4
20	23.4
21	23.3
22	23.1
23	23.1
24	23.3
25	23.9
26	24.4
27	24.5
28	24.2
29	23.7
30	23.3

Table 3

See graph 4 for graphic representation of the running mean (table 3).

Two frequency histograms were plotted (see graphs 2 and 3), to show the differences the wave exposure made, and to see whether the data was normally distributed hence deciding which statistical test to use. The T test was chosen because the data is normally distributed and it will show the differences between the two means of information collected from the two sites, and show me whether the differences between the two sites are purely coincidental or whether it is due to the difference in wave exposure.

See appendix for calculations and results for the t test.

Analysis

The abiotic factors at the two sites, mentioned in the methodology are all fairly similar to each other. This means that it can be said that any differences discovered between the morphology of *F. vesiculosus* at the two sites is solely down to the different levels of wave exposure.
From graph no. 1 it would seem at first glance that there is a positive correlation, but on closer inspection, it is not very clear. This is why a statistical test is needed; to show whether the results mean anything, or whether it is just chance.
The results show that at Instow, the *Fucus vesiculosus* plants generally have a much higher air bladder count, than the plants at Abbotsham. This is almost definitely due to the sheltered position of Instow. There is hardly any turbulence and so therefore the plants do not get raised upwards to the sunlight by the movement of the water. Obviously the plants need sunlight for photosynthesis so instead they need to provide themselves with the ability to float, hence the growth of more air bladders.
The results also show that the lengths of the *F. vesiculosus* were greater at the highly wave exposed site, Abbotsham. This was not expected. A reason for this result may be down to the fact that at Instow, because of less turbulence, the plants don't get ripped away from their holdfasts by the waves. This means that there are more plants closer together, which shade each other when dry, as they lay on top of each other, and also when submerged, as they are so close that when their fronds sway they stop the sunlight from reaching neighbouring plants.

Photophosphorylation, a process in photosynthesis that converts ADP and inorganic phosphate into ATP, needs light energy to work. When chlorophyll a absorbs light it causes one of its electrons to have a raised energy level. This electron can then leave the chlorophyll molecule and get passed along a chain of electron carriers, known as an electron transport system. Many electrons pass down this chain in a series of redox reactions, releasing energy used to make ATP. If the plant does not get sufficient light, then not much ATP can be produced in the light dependent stage. If not enough ATP has been produced in the light dependent stage, then it cannot be used in the light independent stage to convert carbon dioxide into glucose in the Calvin cycle. Therefore the plant cannot grow.

Another possible reason for the plants being longer at Abbotsham is that at Instow there is a very high population of *Ascophyllum nodosum,* commonly known as egg wrack, which is probably also competing with the *F. vesiculosus,* as it also inhabits the mid zone of rocky shores. *Ascophyllum nodosum* secretes mucilage, and perhaps a reason for the *F. vesiculosus* being shorter, is that the *A. nodosum* is allelopathic. Allelopathy is the secretion of chemicals by one plant to keep other species away from it, so the plant has space, and light for photosynthesis. They do this by either releasing growth compounds from their roots or, probably more likely in this case, chemicals that change the amount of chlorophyll in the surrounding plants, causing photosynthesis to slow down, therefore slowing down the production of glucose, and the plant's growth.
Some examples of allelopathic plants, also known as interspecific competition plants, are the black walnut tree, *Juglans nigra,* and the common sunflower.

Evaluation

This investigation has been successful in that it has proved that wave exposure has an effect on the morphology of *Fucus vesiculosus.* To obtain the highest level of accuracy, a continuous transect along the beach would have perhaps given more precise results as a larger percentage of the population would have been taken into account.

To find out more about the effect of wave exposure o the morphology of *F. vesiculosus*, the investigation would have to be taken further afield and more beaches would have to be sampled, all with different levels of wave exposure. This investigation can only be relevant to sheltered and semi exposed shores like Instow and Abbotsham.

If there were more dependent variables then the results would also say more about the specific effects of wave action and more links could be made and detailed conclusions drawn about the effect it has on many aspects of the morphology of the seaweed.

The results of the investigation could have been presented in other ways, which would make more trends visible, maybe including more statistical tests for proof of any more trends possibly found. The results obtained are quite restricted in terms of how they can be interpreted, but had more results been obtained, more options would have been available as to how they could have been interpreted.

Conclusion

The effect of wave exposure on the morphology of *Fucus vesiculosus* is that, according to this investigation, the less exposed the plants are to waves, the more air bladders they have. Seaweed more exposed to waves tends to be longer, and have less air bladders.

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APPENDIX

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