Leeds. Oct. 22. 1891

Dear Darwin,

I have not finished with Nymphæaceæ, but will break off to mention some observations on Duckweed, which I have been attending to for a few days past.

VI. Lemna minor.

It is taught in physical books that floating bodies which are wetted by water attract one another; that those which are not wetted also attract one another, but that if one body is wetted & another not, they repel one another. It might therefore be expected that the fronds of Duckweed would always attract one another, & be attracted by the sides of the pond; that they would gather round the sides in dense masses, & if blown or otherwise removed into the centre of the pond, would form dense patches there.

On observing in still weather a pond rather scantily overgrown with Duckweed I could see no such distribution of the fronds.

There were small patches here & there, & thin clusters round floating bodies, posts &c. Now & then a very indefinite radiating arrangement could be seen. But the general tendency was to form strings, simple or branched, often several fronds broad; the intervening spaces were most irregular, sometimes wide, sometimes narrow. Many isolated fronds or very small clusters were seen. I have since repeatedly placed parcels of fronds upon the surface of water in basins, aquaria, &c., & have seen the same kind of distribution. Dense masses do not form until the surface is nearly covered, but the fronds arrange themselves in strings, & these are tolerably spaced so long as enough unoccupied ~~space~~ surface remains.

This tendency gives obvious advantages to a plant which increases rapidly by lateral budding. Were the fronds closely packed by mutual attraction, it is not easy to see how the central ones could continue to multiply.

In order to find out how the

arrangement in strings is brought about I examined a few single fronds. The typical shape, which is subject to some variation, is this (fig. 1). The dotted line represents a ridge which runs along the principal axis, subsiding at the broad end. New fronds form towards the narrow end on each side (fig 2) & each pushes out its broad end first. At the narrow end there is often a small scar or prominence, which indicates the previous attachment to the parent frond.

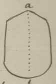


fig 1.

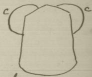


fig 2

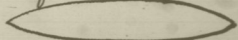
The periphery of the frond is not coplanar. In some places it is raised above the surface of the water, while in others it is depressed. At a (fig 1) it is raised; at b it is also raised, but to a slighter extent; between these points it is depressed. The edges of the young fronds, c c (fig 2) are also as a rule slightly turned up. All such raised parts form centres of attraction. If a small splinter of wood or any similar object, wetted by water, is brought near such a centre, the frond is visibly attracted, but if brought near to any other part of the edge, the frond is indifferent or even feebly repelled. By holding the needle or splinter in a vertical position, a millimetre or two away from one of the centres of attraction, & moving it slowly round in a circle, the frond can be made to rotate about its own centre, without ever being touched. This movement is much checked by the long root, especially if the root is not vertical. If the root is cut off, the frond becomes very sensitive to the attraction of a needle or splinter.

Wherever the periphery rises a little above the surface of the water, the capillary curve turns up, as the reflections from the surface show, & here is a point or line of attraction for a solid wetted by water. Where it sinks below the surface the capillary curve turns down, & here is a point or line of indifference or repulsion for a solid wetted by water.

a, centre of attraction. b, centre of repulsion for solid wetted by water.

Two centres of attraction attract one another. Two centres of repulsion are relatively indifferent to one another, in consequence of the mutual attraction of the adjacent centres of attraction.

As every normal single frond has two centres of attraction, & every normal budding frond three or sometimes four, there is a tendency for the fronds to cohere by these points, & so form strings, which are often branched. The effect can be illustrated by a model. Cut up a bit of card into pieces of the shape indicated. Slightly



turn up the two points, & float the pieces on water, with the turned up points directed upwards. These points constitute centres of attraction, & the pieces of card soon form rosettes & other figures, but cannot be got to remain side by side, or to occupy any position which is economical of space. After floating an hour or so, the cards become limp, the points subside, & the cards take any position.

Fronds accidentally isolated remain so for a long time, as the attractions are very feeble beyond short distances. The viscosity of the surface-film, owing to contamination with dust, decaying organic matter, &c. is usually considerable, & may altogether neutralise the attractive force, even at moderate distances.

Thanks for your last letter. I will think over the points mentioned. I feel very much in the dark on almost every point, & am thankful to get a glimmer of light now & then.

Yours very truly,

L. C. Miall.